CHAPTER 4. PAINTING OPERATIONS

Section 1. PAINT SHOP

4.1.1 FUNCTIONS. The paint shop is used for storage, paint preparation, and painting of small items. It provides storage space for painting equipment and limited stocks of paints and paint materials. It is used for preparing paints for field use, i.e., conditioning, mixing, limited testing, thinning, and straining. Special ventilated booths are located in the paint shop for spraying and drying small items. Lettering and sign painting are also done in this area.

4.1.2 PLANNING AND LAYOUT. Locate the paint shop in a firesafe area with all paint storage cabinets of noncombustible construction (see 4.2.3). Provide adequate space, facilities, heating, lighting, and mechanical ventilation for storage, paint preparation, and sign painting. Facilities include spray booths large enough to allow spraying of the largest anticipated signs or other items which will be painted. These booths should be of the water-wash type, capable of removing all fumes without leaving any solvent vapor in the working area. Provide all necessary safety equipment (see Chapter 3) and post appropriate warning signs designating danger areas within the shop. For example, paint storage cabinets should be marked, "Danger, Flammable. Keep Flame and Excessive Heat Away." “No Smoking" signs should be posted at several locations within the shop. Equip the paint shop with all equipment, tools, and supplies required for paint mixing, limited testing, thinning, and straining, surface preparation, and application by brush, roller, or spray. Also provide all doors, windows, and equipment storage spaces with adequate locking devices.

4.1.3 EQUIPMENT OPERATION AND MAINTENANCE. Cleaning of spray booths, either by scraping or high pressure washdown, should be performed at frequent intervals. Apply a thin coating of a water soluble material such as a liquid soap to the walls of spray booths to collect excess spray.

See Standard No. 33 of the National Fire Protection Association for details concerning the operation and maintenance of paint spray booths and associated equipment.

Section 2. PAINT MATERIALS

4.2.1 PROCUREMENT. Purchase all paint materials in accordance with applicable procurement regulations. Procurement is to be by requisition, competitive bids, or by open market purchases.

Procurement by open market purchases is to be undertaken only for small orders when rapid delivery is essential, or for special projects. Refer to the General Services Administration Federal Supply Service Stores Stock Catalog for paint materials available from their stock.

4.2.2 SAMPLING AND TESTING. Specification paint materials furnished by a contractor or procured on the open market will be tested to determine acceptability before use. Tests will be made by a qualified Government or qualified independent testing laboratory to insure compliance with applicable specifications. Limited testing will also be done just prior to use (see 4.2.2.2).

4.2.2.1 Sampling Procedure. Select samples from each lot of paint purchased by the Government or supplied by the painting contractor. A representative of the contractor should be present to certify, in writing, that the sample was properly taken. Samples will be a full gallon if the paint is delivered in 2 gallon containers, or 2 quarts if the paint is delivered in other sizes. Before taking a sample from a larger container, mix the paint thoroughly until it is of the same consistency from top to bottom. Inspect containers to determine that full measure has been received. Record the following on each sample container:

a. Number and exact title of specification including amendment or revisions, also class or type of paint

b. Manufacturer's name and address

c. Contractor's name and contract number when applicable

d. Batch or lot number

e. Date of manufacturer

f. Number of gallons represented by the sample.

Forward the samples to the laboratory with a written request for the tests required, whether for full compliance or the specific test desired. Include the above information in the request form.

4.2.2.2 Inspection and Paint Shop Testing. It should not be necessary to sample paint materials when it is known, by actual test, that the paint complies with specification requirements. Limited testing should be done when preparing the paint for use and during painting operations by contractors, to determine if paints have been adulterated. Limited field testing should not be considered as a substitute for standard professional laboratory techniques. Field testing does serve to discover major flaws or adulteration in a coating material. Sampling on the job is done by the paint inspector or his qualified representative (see 4.2.2.1).

Check for the following properties:

a. Weight per Gallon: Weigh an empty gallon can; then weight a full gallon of the paint. The difference between these two weights gives a close enough approximation to the number of pounds of material which is included in each gallon of paint. The result should be within the requirements outlined in the product specification. Any greater variation may indicate improper mixing or unauthorized addition of thinners.

b. Application Properties, Dry Time, and Appearance: Brush the paint on to a substrate which is similar to the substrate which will be coated and hang it vertically to dry. If the paint is intended for brush application, note its brushing qualities. Check to see if it dries within the specification limits. After it has dried, note its appearance and compare it with specification standards for such properties as gloss, color, leveling, and resistance to sagging.

4.2.3 MATERIALS STORAGE

4.2.3.1 Storage Areas. Store paint materials in warm, dry, and well ventilated areas. The best temperature range is 65° F to 85° F. Low temperatures cause paints to increase in viscosity and require conditioning for 24 hours before use. Freezing temperatures may ruin water-thinned paints and may also cause containers to bulge or burst. Conversely, high temperatures will cause paints to thin down and settle more rapidly. If the coating material is sensitive to heat, temperatures over 100° F may bring about reactivity within the container resulting in a viscosity increase to the point of gelation. Such paints are then not usable. Also, pressure build-up may cause covers to blow off, creating a serious fire hazard. Application is seriously affected when paint materials are drawn from stocks in overly cold or warm storage. Additional conditioning time and efforts are required to ensure proper application and maximum surface protection. Other factors to be considered are high humidity, which causes containers to corrode and labels to deteriorate, and poor ventilation which allows the collection of excessive concentrations of solvent vapors that are both toxic and combustible. Pumps for drawing liquids from steel drums must be of the type approved by fire underwriters. Do not use gravity spigots other than self-closing types for that purpose. Stock should be stored so that all labels can easily be read and so that containers can be rotated to use up older material first.

Provide an orderly method of maintaining records of paints entered into storage as well as an appropriate system of arranging paint materials in storage to be certain that all like types and colors are kept in their designated sections.

4.2.3.2 Issue. Issue paint materials so that oldest stocks are used first. Make all paints ready for use before issuance, e.g., conditioned at the proper temperature and mixed thoroughly. Avoid using leftover paint but, if necessary to do so, condition and strain before issuance.

4.2.3.3 Containers. Store paint material in full, tightly sealed containers. Avoid partially filled containers. Try to use paint on the job so as to have little or none left over (accuracy in advance estimating will accomplish this). It is safer to discard small quantities than to use paint that has skinned. Otherwise, place leftover paint in smaller containers, filling them full, and seal. Be certain to copy all information from the original container and mark this directly on the new container as follows:

a. Name or title of paint

b. Specification number

c. Stock number

d. Manufacturer

e. Date of manufacture

f. Contents by volume

g. Color

h. Batch number

i. Instructions for use.

4.2.3.4 Storage. Store smaller containers, e.g., 1/4- , 1- , 2- , and 5-gallon cans on shelves or in cabinets constructed of noncombustible materials. Store full drums either vertically on pallets on concrete floors, or horizontally on steel racks. Refill partially used drums into 5-gallon cans to prevent skinning. Storage spaces must be firesafe (see NFPA Standard No. 30 for guidance). Forbid smoking or open flames in the area. Post all necessary precautionary signs throughout the area. Take adequate safeguards as to temperature, humidity, and ventilation (see 4.2.3.1).

4.2.4 DEFECTIVE PAINT MATERIALS. Activities or installations may contact the appropriate Command office, listed below, to obtain information or assistance on disposal, evaluation, replacement, or use of material when faulty coating materials are encountered.

HQDA (DAEN - MPO- B)
Washington, DC 20314
or
Naval Facilities Engineering Command
200 Stovall Street Code 0454B
Alexandria, VA 22332
or
HQAFESC/DEM
Tyndall AFB-FL 32403

In addition; Public Works, Maintenance, Inspection, or Engineering personnel should be encouraged to obtain and communicate the following data when unsatisfactory coatings are encountered.

a. Complete data from the label, Federal stock item number (if applicable), specification number, color, container size, batch number, date of manufacture, and name of the manufacturer.

b. Condition in container such as mold growth, livering, skinning, putrefaction, lumps or particles, corrosion in container, permanent settling of pigment, color not as specified, putrid or irritating odor, or other.

c. Working properties, such as difficulty in application by brush, roller, or spray streaking, lifting, running, sagging, pinholes, incompatibility with thinner, or other.

d. Appearance of applied paint, whether sagging, pinholes, streaking, conspicuous laps, objectionable brush marks, or other.

e. Type of work, whether new construction or maintenance, exterior or interior. Also job number, installation, site, organization, and date.

Section 3. PAINT CONDITIONING AND MIXING

4.3.1 GENERAL. Essentially, paints consist of two principal components--the solid pigment and the liquid vehicle. The purpose of conditioning and mixing is to redisperse or reblend settled pigment with the vehicle, to eliminate lumps, skins, or other detriments to proper application, and to bring the paint materials to their proper application temperature. All paint materials should be placed in the paint shop at least 24 hours before use in order to bring their temperatures between 65° F and 85° F. After this time paints are mixed, thinned, or tinted, if specified, and finally are strained, if necessary.

4.3.2 MIXING. Mix paint materials in the paint shop just prior to issuance. Mixing procedures will vary among different types of paints. Regardless of the procedure used, take care to avoid the incorporation of an excess of air through overmixing. Table 4-1 outlines the type of equipment and procedure to be followed for various types of coatings. Mixing is done by either manual or mechanical methods, but the latter is definitely preferred to ensure maximum uniformity. The two most commonly used types of mechanical mixers are those which vibrate the full, sealed container, and those which utilize propellers that are inserted into the paint. vibrating shakers are used for full containers, up to 5 gallons. Propeller mixers are used for containers ranging from 1 quart or larger. (See Figures 4-1 through 4-3.) Manual mixing is less efficient than mechanical methods in terms of time, effort, and results. It is to be done only when absolutely necessary and should be limited to containers no larger than 1 gallon. Five gallon containers may be stirred manually, if done with care. To accomplish this, half of the paint is poured off into an empty container and the remainder is then stirred thoroughly, being certain to scrape off and break up any settled matter on the bottom or lower sides of the container. Stirring is continued as the other half of the paint is returned slowly to the original container. The stirred paint must have a completely blended appearance with no evidence of varicolored swirls at the top, indicating unmixed pigment or vehicle. Neither should there be evidence of lumps indicating the presence of unredispersed solids or foreign matter. (See Figure 4-4.)

4.3.2.1 Sequence of Operations. Complete conditioning and mixing of ready mixed paints (as received) is mandatory prior to introducing thinners or other additives, and these must be thoroughly blended into the paint after being introduced. In addition, use the same conditioning of multi-component paint materials before mixing. Manufacturers' label directions regarding proper mixing are to be strictly followed.

4.3.2.2 Boxing. Paints tend to settle during storage. To ensure that they are uniform, box all paints before use. (See Figure 4-4.) If different production batches are used (check batch numbers), compare them for color and gloss after boxing. If any differences are observed, either use them in different areas or box enough for the job using larger containers.

4.3.3 TINTING. Avoid tinting as a general practice. Purchase paints in the desired color to minimize waste and errors in on-the-job tinting. This procedure also eliminates the problem of matching special colors at a later date.

TABLE 4-1
Mixing Procedures

Coating	Equipment	Remarks
Enamel, semigloss or flat paints (oil type)	Manual, propeller or shaker	Mix until homogeneous.
Water based paints (latex type).	Manual or propeller.	Use extreme care to avoid air entrapment.
Clear finishes	Manual, propeller or shaker	Generally require little or no mixing.
Extremely viscous finishes, e.g., coal tar paints.	Drum-type mixer	Use extreme care to avoid air entrapment.
Two package metallic paints, e.g., aluminum paints	Propeller.....	Add small amount of liquid to paste; mix well. Slowly add remainder of vehicle, white stirring, until coating is homogeneous. With metallic powder, first make into a paste with solvent, and then proceed as above.
Two component systems....	Propeller, shaker, or drum-type mixer.	Mix until homogeneous. Check label for spec ial instructions.

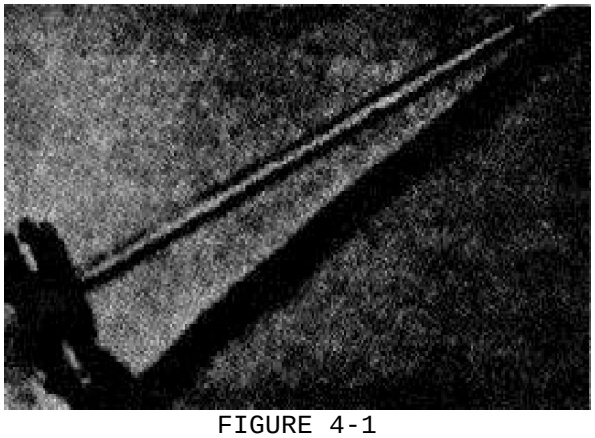


FIGURE 4-1
Paint Mixer-Drill Attachment

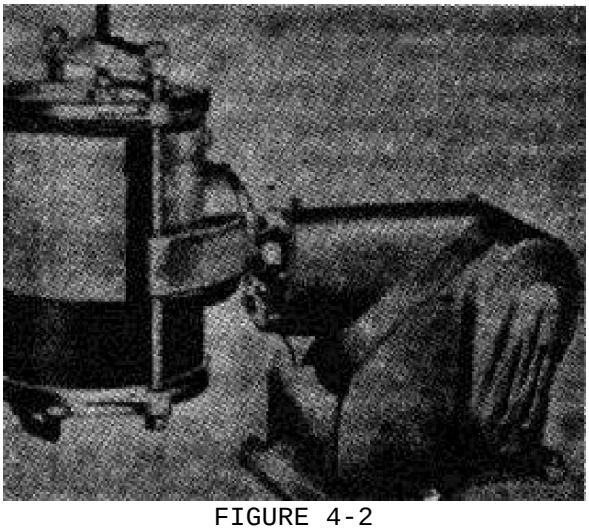


FIGURE 4-2
Paint Mixer-Vibrating Shaker

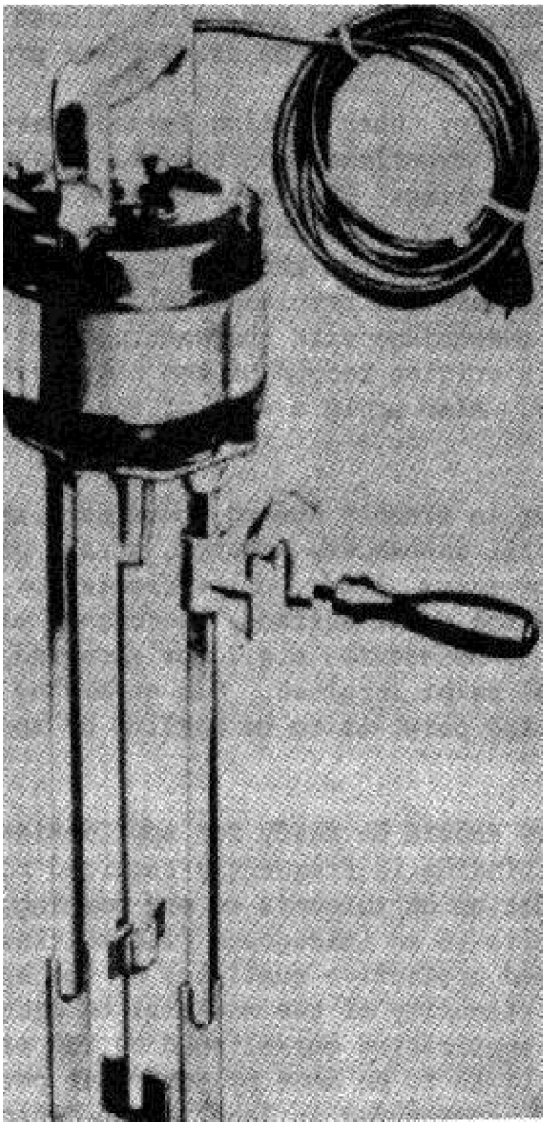


FIGURE 4-3
Paint Mixer-Propeller Type

One exception is the tinting of intermediate coats which is done to differentiate between that coat and the topcoat so as to ensure that there are no missed areas. Tinting colors affect the properties of the paint to which they are added, often reducing performance to some extent. Tinting should be done with care. Use only colors which are known to be compatible, and, add no more than 4 ounces per gallon of paint, if at all possible. Never use more than 8 ounces per gallon, otherwise, the paint may not dry well and will surely be degraded in performance. Do not tint chalking type exterior paint except for identification of intermediate coats.

4.3.3.1 Tinting Colors. There are two types of colors used for tinting: colors-in-oil and universal tinting colors.

a. Colors-in-oil are limited to use with standard paints based on oil, alkyd resin, chlorinated rubber and butadiene styrene resin. They cannot be used with the other synthetics or with water thinned paints.

b. Universal tinting colors are used in the same manner as colors-in-oil. They are much more compatible with a wide variety of paint materials. Many can be used with both solvent-thinned and water-thinned paints. Follow the manufacturer's directions carefully when using these products.

4.3.3.2 Tinting Procedure. When tinting is necessary, it should be done in the paint shop and only by experienced personnel. The paint must be at application viscosity before tinting. Colorants must be compatible, fresh and fluid, so as to mix in readily. Mechanical agitation is of utmost importance to insure uniform color distribution throughout the applied paint. Avoid overmixing (see 4.3.2). Test the resultant color by applying the paint and allowing it to dry for comparison with the manufacturer's reference chip, if one is used. Maintain a written record of the tinting formula and mark the container appropriately. Also apply a spot of the final paint to the can cover as a further reference.

4.3.4 STRAINING. Paint in freshly opened containers should not normally require straining. In all instances, however, strain paints after mixing, if there is any evidence of skins, lumps, color flecks, or foreign materials. First remove skins from the paint surface, thoroughly mix the paint, thin to application viscosity, if necessary, e.g., for spraying, then strain through a fine sieve or commercial paint strainer. Use straining as a standard procedure in all instances where the paint is to be applied by spray to avoid clogging of the spray gun.

4.3.5 THINNING. Paints should be ready for application by brush or roller when received. While thinning is frequently required for spray application, avoid the arbitrary addition of thinners to any coating. Unnecessary or excessive thinning results in an inadequate film thickness and drastically reduces the longevity and protective qualities of the applied coating. In all instances, measure the viscosity of the material to determine that it is correct for the method of application established by the manufacturer. When thinning is necessary, it is to be done by competent personnel using only compatible thinning agents recommended in label or specification instructions. Thinner can be added for brush or roller application with only prior approval of the supervisor or inspector. Do not thin to improve brushing or rolling of paint materials which are overly cold. These should be pre-conditioned to bring them up to 65° F to 85° F.

Section 4. PREPARATION OF SURFACES

4.4.1 GENERAL. Proper preparation of the surface prior to painting is essential to achieve maximum life of the coating. The best quality paint will not perform effectively if applied on a poorly prepared surface. The initial cost of inadequate surface preparation is more than compensated for by increased durability, minimum repairs, and repainting. The selection of surface preparation systems is dependent upon:

a. Nature of substrate
b. Condition of surface to be painted
c. Type of exposure
d. Practical limitations, i.e., time, location, space, and the availability of equipment

e. Economic considerations
f. Type of paint to be applied
g. Safety factors.

Many surface contaminants reduce adhesion and cause blistering, peeling, flaking, and underfilm rusting. Among these contaminants are: dirt, grease, rust, rust scale, mill scale, chemicals, moisture, and efflorescence. In addition, the following surface defects will affect adhesion adversely: irregular weld areas, metal burrs, crevices, sharp edges, irregular areas, weld splatter, weld flux, knots, splinters, nail holes, loose aggregates, and old paints in various stages of failure. Because of its importance, methods of preparing iron and steel for painting are given particular emphasis in the following paragraphs.

4.4.2 MECHANICAL TREATMENT.

4.4.2.1 Hand Cleaning. Hand cleaning will remove only loose or loosely adhering surface contaminants. These include rust scale, loose rust, mill scale, and loosely adhering paint. Hand cleaning is not to be considered an appropriate procedure for removing tight mill scale and all traces of rust. In general terms, hand cleaning cannot be expected to do more than remove major surface contamination. As such, it is primarily recommended for spot cleaning in areas where corrosion is not a serious factor. In extreme situations, as when areas are not accessible to power tools, hand cleaning may have to be used by necessity. Inasmuch as hand cleaning will remove only the loosest contamination, primers are required which will thoroughly wet the surface. All applied coats must be capable of overcoming the interference of contaminants left behind after hand cleaning to achieve satisfactory adhesion, assuring maximum anticipated coating life under normal conditions. Before hand cleaning, the surface must be free of oil, grease, dirt, and chemicals. This can best be accomplished with solvent cleaners (see 4.4.3). Then remove rust scale and heavy build-up of old coatings with impact tools such as chipping hammers, chisels, and scalers. Remove loose mill scale and non-adhering paint with wire brushes and scrapers. Finish up by sanding, especially on woodwork. All work must be done to avoid deep marking or scratches on the surface by the tools used. (See Figure 4-5.) Start painting as soon as possible after cleaning.

4.4.2.2 Power Tool Cleaning. Power tool cleaning methods provide faster and more adequate surface preparation than hand tool methods. Power tools are used for removing small amounts of tightly adhering contaminants which hand tools cannot remove, but they remain uneconomical and time consuming as compared with blasting for large area removal of tight mill scale, rust or old coatings. Power tools are driven either electrically or pneumatically and include a variety of attachments for the basic units. Chipping hammers are used for removing tight rust, mill scale, and heavy paint coats. Rotary and needle scalers are used for removing rust, mill scale, and old joint from large metallic and masonry areas. Wire brushes (cup or radial) are used for removing loose mill scale, old paint, weld flux, slag, and dirt deposits. Grinders and sanders are used for complete removal of old paint, rust, or mill scale on small surfaces and for smoothing rough surfaces. As with hand tools, care must be exercised with power impact and grinding tools not to cut too deeply into the surface, since this may result in burrs that are difficult to protect satisfactorily. Care must also be taken when using wire brushes to

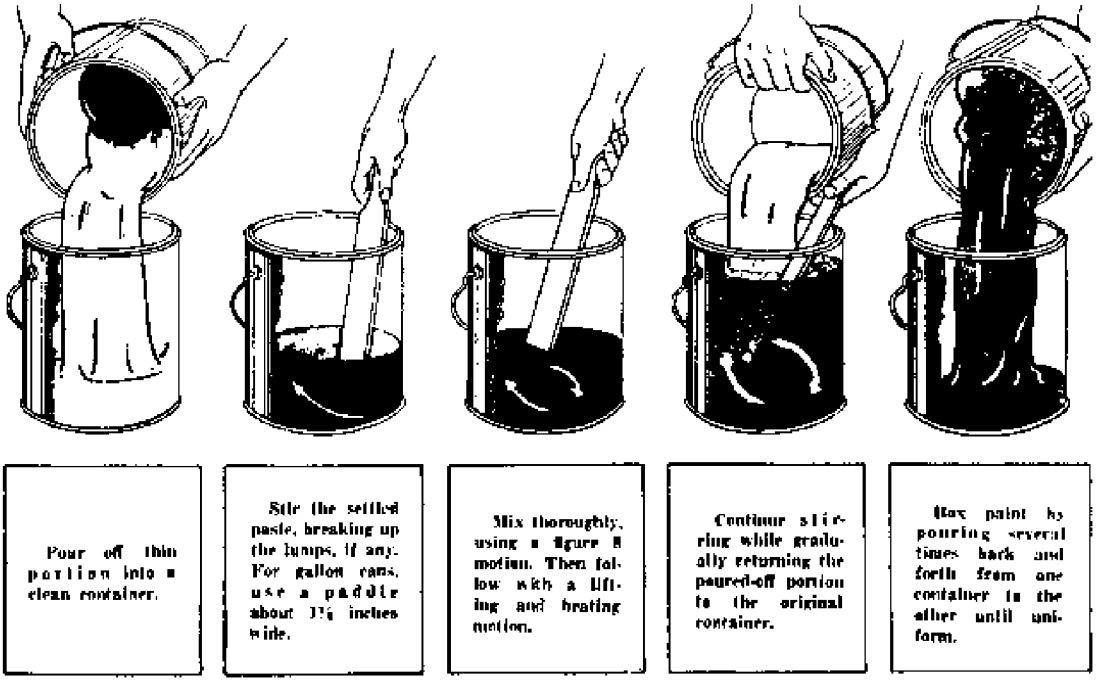


FIGURE 4-4
Manual Mixing and Boxing

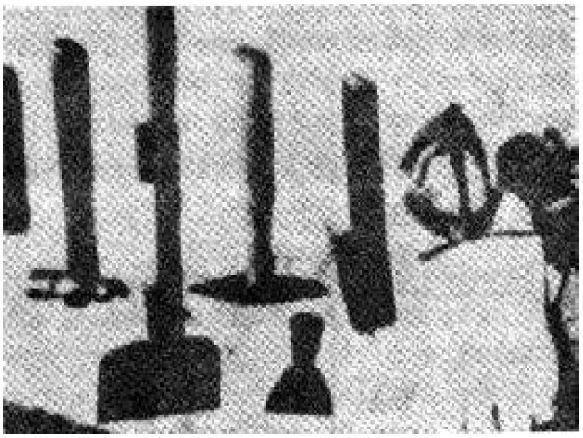


FIGURE 4-5
Hand Cleaning Tools

avoid polishing metal surfaces and thus prevent adequate adhesion of the subsequent coatings. Power tool cleaning is to be preceded by solvent or chemical treatment and painting must be started and completed as soon after power cleaning as possible. (See Figures 4-6 through 4-11.)

4.4.2.3 Flame Cleaning. (For Metal Only) Flame cleaning is a method of passing high velocity oxy-acetylene flames over a metal surface. This method is satisfactory for both new and maintenance work. Oil and grease must be removed prior to flame cleaning both for safety and adequacy of preparation. Wire brushing normally follows flame cleaning to remove loose matter. Extreme caution is necessary to prevent accidents from the flame, and adequate ventilation must be provided during the process. The coating is applied while the substrate is still warm, thereby speeding up drying time and also permitting painting when ambient temperatures are somewhat below 50° F. However, avoid painting until completion of the cleaning operation because the flame presents a definite fire hazard with solvent thinned paints. (See Figures 4-12 and 4-13.) See also Steel Structures Painting Council SSPC-SP4.

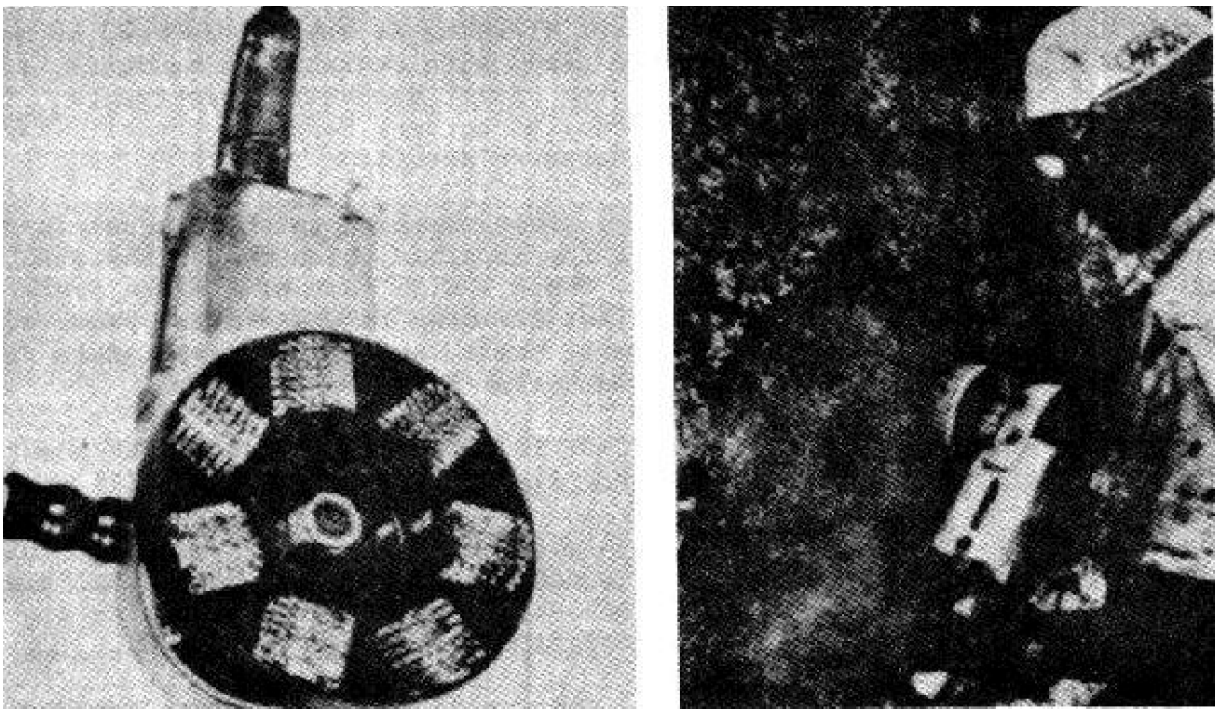


FIGURE 4-6
Typical Power Grinding Tool

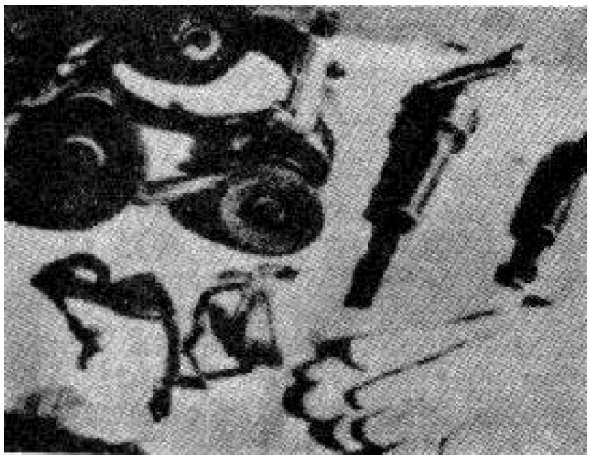


FIGURE 4-7
Air Powered Cleaning Tools

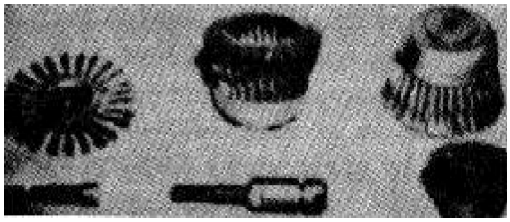


FIGURE 4-8
Power Tool Wire Brushes

4.4.2.4 Blast Cleaning. Blast cleaning abrades and cleans through the high velocity impact of sand, metal shot, metal, or synthetic grit or other abrasive particles on the surface. Blast cleaning is most often used on metal structures in the field but may also be used, with caution, on masonry substrates. It is, by far, the most thorough of all mechanical treatments. There are four degrees of blast cleaning. Steel Structures Painting Council (SSPC) Manual No. 2 should be referred to for greater detail.

a. White Metal Blast: (SSPC-SP 5) Blast cleaning to white metal is the ultimate in blast cleaning. It is used for coatings which must withstand exposure to very corrosive atmospheres, where a high cost of surface preparation is considered to be warranted. Blast cleaning to white metal provides for the complete removal of all rust, mill scale, and other contaminants from the surface. This will assist in maximum paint system performance.

b. Near-White Metal Blast: (SSPC-SP 10) In this procedure the blasted surface will show shadows, streaks and/or discolorations but they will appear across the general surface area and not be concentrated in spots. Thus, the evaluation of the completed cleaning job must be of a visual judgment. This preparation effects a 10 percent to 35 percent savings over white metal blasting and has proven to be sufficiently adequate for many of the special coatings developed for long-term protection in moderately severe environments.

c. Commercial Blast: (SSPC-SP 6) Commercial blast describes the removal of all loose scale, rust, and other surface contaminants. This method of surface preparation will result in a high degree of cleaning, and is generally considered adequate to the long life of the majority of paint systems under normal exposure conditions.

d. Brush-Off Blasting: (SSPC-SP 7) This is a relatively low cost method of cleaning to remove old finishes in poor condition, loose rust and loose mill scale. Brush-off blasting is not intended for use where severe corrosion

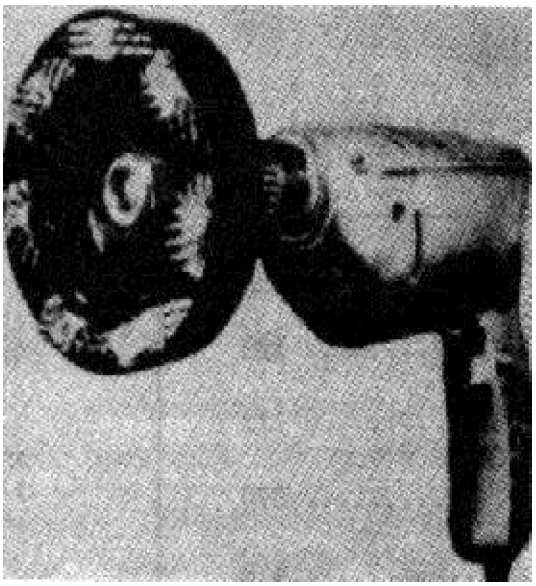


FIGURE 4-9
Typical Drill Attachment Tool

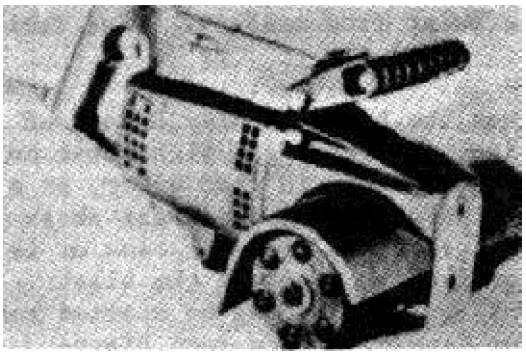


FIGURE 4-10
Rotary Impact Cleaning Tool

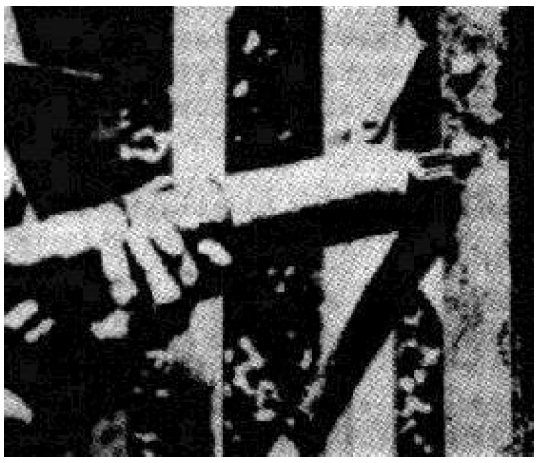


FIGURE 4-11
Needle Scaler

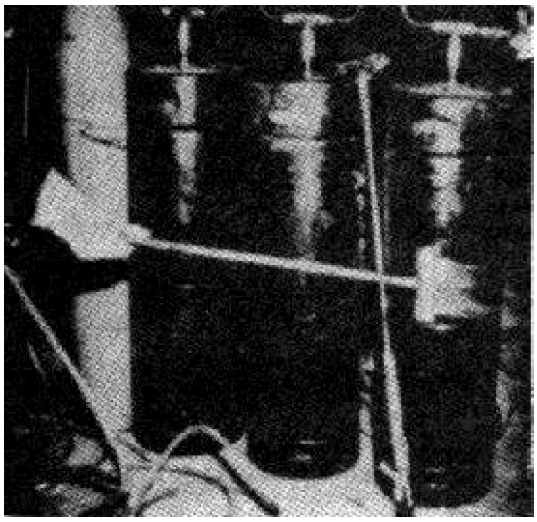


FIGURE 4-12
Flame Cleaning Equipment

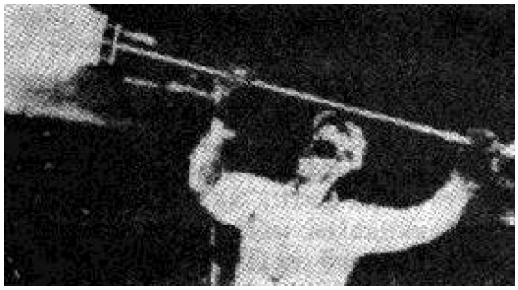


FIGURE 4-13
Flame Cleaning

TABLE 4-2
Rate of Cleaning

(Approximate cleaning rates using 100 psi
with a 5/16 in nozzle)

	ft^2/hour
White metal	100
Near-white	175
Commercial	370
Brush-off	870

is prevalent, but is, instead, intended to supplant hand tool and power tool cleaning where blast-cleaning equipment is available. The brush-off method is also used for the removal of loose or degraded paint from masonry. (See Table 4-2.)

4.4.2.5 Procedures. Blast cleaning involves the high velocity impact of abrasive particles on the surface. The abrasive is discharged, either wet or dry, under pressure. The wet system differs from the dry in that water, or a solution of water and a rust inhibitor, is incorporated with the blast abrasive. The water is either mixed with the abrasive in the pressure tank or is introduced into the blast stream just behind or just in front of the blast nozzle. All blasted metal surfaces require that prime painting be started and completed the same day to prevent new rust from forming, since such blast-cleaned surfaces are subject to rapid rusting if not coated. Metal or synthetic shot, grit, or similar abrasives are used where recovery of the abrasive is possible. Sand is used when the agent is expendable, but this is a costly procedure. The grit, in any case, must be of a size sufficient to remove surface contamination without working the surface to excess. Overworking creates extreme peaks and valleys (anchor pattern) on the surface which require an additional build-up of the applied paint film for adequate protection. The peaks, even then, if too high, represent possible areas of premature paint failure (See Table 4-3.)

a. Dry Blasting: There are two general methods of dry blasting: conventional and vacuum.

(1) Conventional Blasting. Conventional blast cleaning is a term used to designate the usual method of field blasting, in which no effort is made to alleviate the dust hazard or reclaim the blast abrasive. (See Figures 4-14 and 4-15.) This procedure precludes the need for special rinsing, as required for wet blasting, but requires that health precautions be taken to protect the operator and other personnel in the area from the fine, abrasive dust. Machinery in the vicinity must also be shielded. After blasting, the surface must be brushed, vacuumed, or air-cleaned to remove residues or trapped grit.

TABLE 4-3
Effect of Abrasive*

	Average mesh	Rate ft^2/hour	Max height of profile (mils)
Steel grit (dry honing)	100	120	1.5
Ottawa sand, very fine	80	175	1.5
Ottawa sand, fine	40	150	1.5
Ottawa sand, medium	18	115	2.0
Ottawa sand, coarse	12	90	2.8
Iron grit - fine	50	100	2.0
Iron grit - medium	25	65	3.2
Iron grit - coarse	16	60	4.5
Iron shot	30	110	2.0
Iron shot	18	75	2.5

*80 psi using 5/16-inch Venturi nozzle at 18-24 inches from mill scale covered mild steel plate.

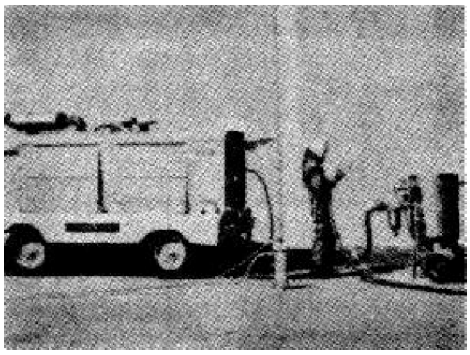


FIGURE 4-14
Dry Blast Cleaning Setup

(2) Vacuum blasting. Vacuum blasting is a relatively new method, which minimizes the dust hazard and in which the blast abrasive is reclaimed. (See Figure 4-16.) This procedure, also known as dry honing, provides for practically no dust to escape and contaminate the atmosphere. The vacuum method of blasting is less efficient than conventional blasting methods on highly irregular surfaces because of the poor vacuum on such surfaces. When the blasting cone is held firmly against the surface to prevent abrasive loss, and the surface is heavily contaminated with rust, algae, or other

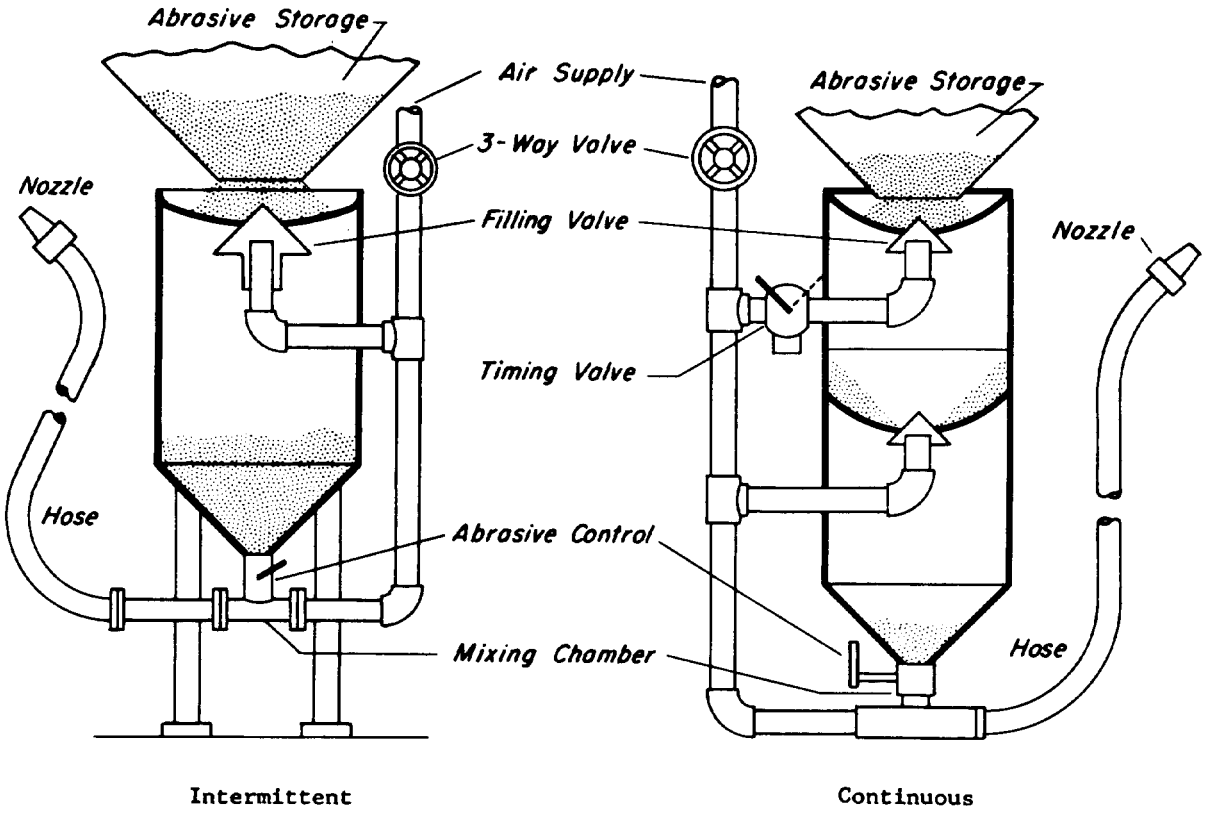


FIGURE 4-15
Direct Pressure Blast Cleaning Tanks

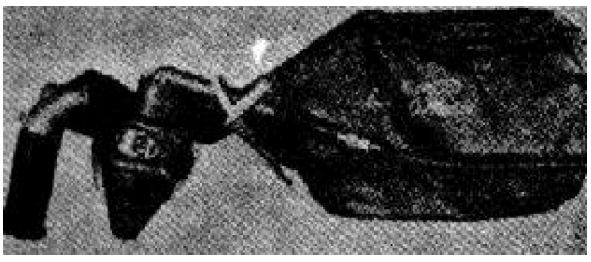
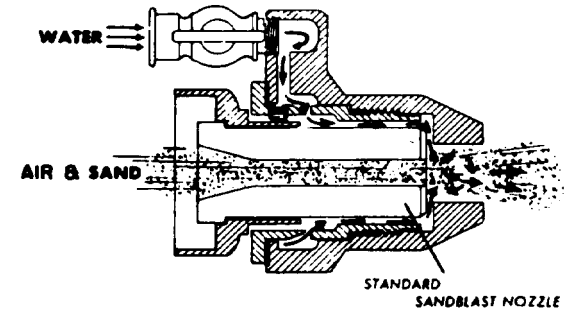


FIGURE 4-16
Vacuum Blast Cleaner



Cross section view of wet blast attachment which sucks water from any water supply for wet blast cleaning.

FIGURE 4-17
Wet Blast Attachment

foreign matter, the machine may not be able to function more than a short time without becoming clogged. In such instances the vacuum blaster is used as a semiopen blasting device, i.e., the cone containing the nozzle is held at a slight distance away from the surface. The dust created is appreciable (workmen must wear respirators) but not nearly as great as with conventional blasting equipment. However, vacuum blasting is very efficient and economical for cleaning repetitive, small-scale surfaces in a shop. The process results in considerable savings in abrasive costs, and also reduces the dust and health hazard.

b. Wet Blasting: (See Figure 4-17.) This method reduces to a minimum the dust associated with blasting, but is not suitable for all types of work. Steel structures, containing a large number of ledges formed by upturned angles and horizontal girders, present a large amount of troublesome cleanup work if the wet method of blasting is used. Wet sand and other blast residues trapped on these ledges are more difficult to remove than dry materials. Also, a sufficient amount of sludge adheres to wet-blasted surfaces to necessitate removal by rinsing, brushing, or compressed air. Moreover, there is a tendency for the wet-blasted surface to rust even though inhibitor is present in the mixing and rinsing water. The blasted surface must be thoroughly dry before coatings are applied.

c. Centrifugal Blaster: (See Figures 4-18 and 4-19.) Large steel plates can be blast cleaned automatically and uniformly before erection. The abrasive grit is dropped into a spinning vaned wheel at a controlled rate. The grit is thus impinged against the steel plate moving beneath it at a predetermined rate. The result is a controlled, uniformly cleaned surface.

4.4.2.6 Precautions. Use goggles, gloves, and dust respirators for all mechanical cleaning operations which create a threat to the health and safety of personnel. (See Chapter 3 and Figure 4-14.) Large amounts of surface grease or oil must be removed by solvent cleaning, prior to blasting (see 4.4.3.1). Avoid dry blasting if temperature of the steel is less than 5° F above the dew point to prevent condensation and subsequent rusting. Where moisture condensation is a problem with dry blasting procedures, a filter/air drier should be placed between hose and compresser.

4.4.2.7 Summary. The principal mechanical surface preparation methods can be classified into four categories according to their increasing order of effectiveness:

Class 1: Nominal cleaning with hand or power tools where the corrosive environment is mild to normal and coatings used will satisfactorily adhere to tight residues normally remaining on surfaces after cleaning.

Class 2: A better grade of surface preparation through flame cleaning or brush-off blasting. It extends the life of the applied coating when the severity of the environment increases.

Class 3: Commercial blast cleaning for preparation required in moderately corrosive atmospheres including immersion in water and exposure to industrial or marine environments.

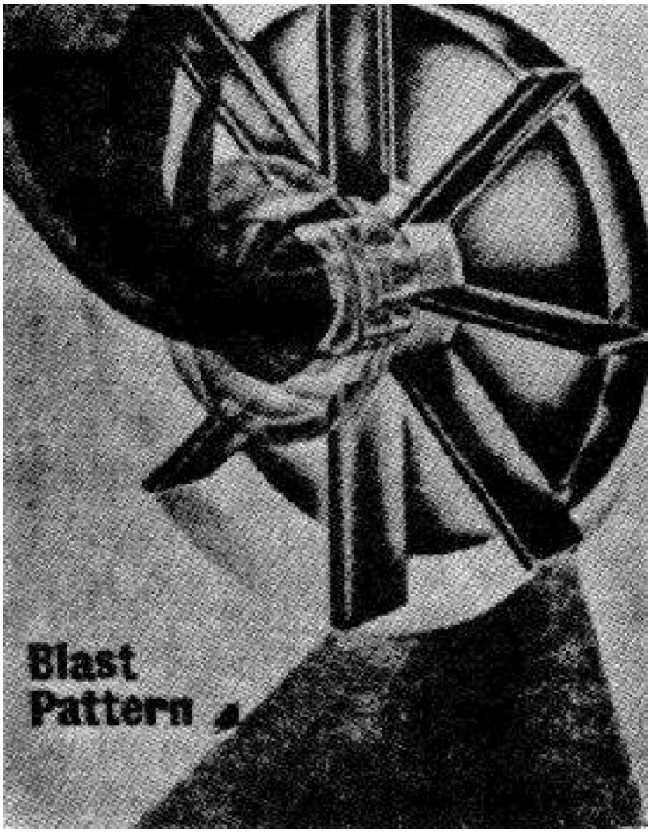


FIGURE 4-18
Centrifugal Blaster--Cutaway View

Class 4: The optimum cleaning procedure including white metal or near-white blasting of ferrous metal surfaces exposed to or in direct contact with strong chemicals, where any degree of rust formation on the surface would be intolerable, or when maximum coating life demands warrant the ultimate in preparation procedures.

Refer to "Pictorial Surface Preparation Standards for Painting Steel Surfaces"--Steel Structures Painting Council SSPC-VIS 1 and ASTM Standard D2200. See also Table 4-4, "Treatment of Various Substrates."

4.4.3 CHEMICAL AND SOLVENT TREATMENT

4.4.3.1 Solvent Wiping and Degreasing. Solvent cleaning is a procedure for removing oil, grease, dirt, chemical paint stripper residues, and other foreign matter from the surfaces prior to painting or mechanical treatment. Solvents clean by dissolving and diluting to permit contaminants to be wiped or washed off the surface. The simplest procedure is to first remove soil, cement spatter, and other dry materials with a wire brush. The surface is then scrubbed with brushes or rags saturated with solvent; Clean rags are used for rinsing and wiping dry. More effective methods include immersing the work in the solvent or spraying solvent over the surface. In either case, the solvent quickly becomes contaminated, so it is essential that several clean solvent rinses be applied to the surface. Mineral spirits is an effective solvent for cleaning under normal conditions. Toxic solvents and solvents with low flash points represent hazards to health and safety. Appendix C

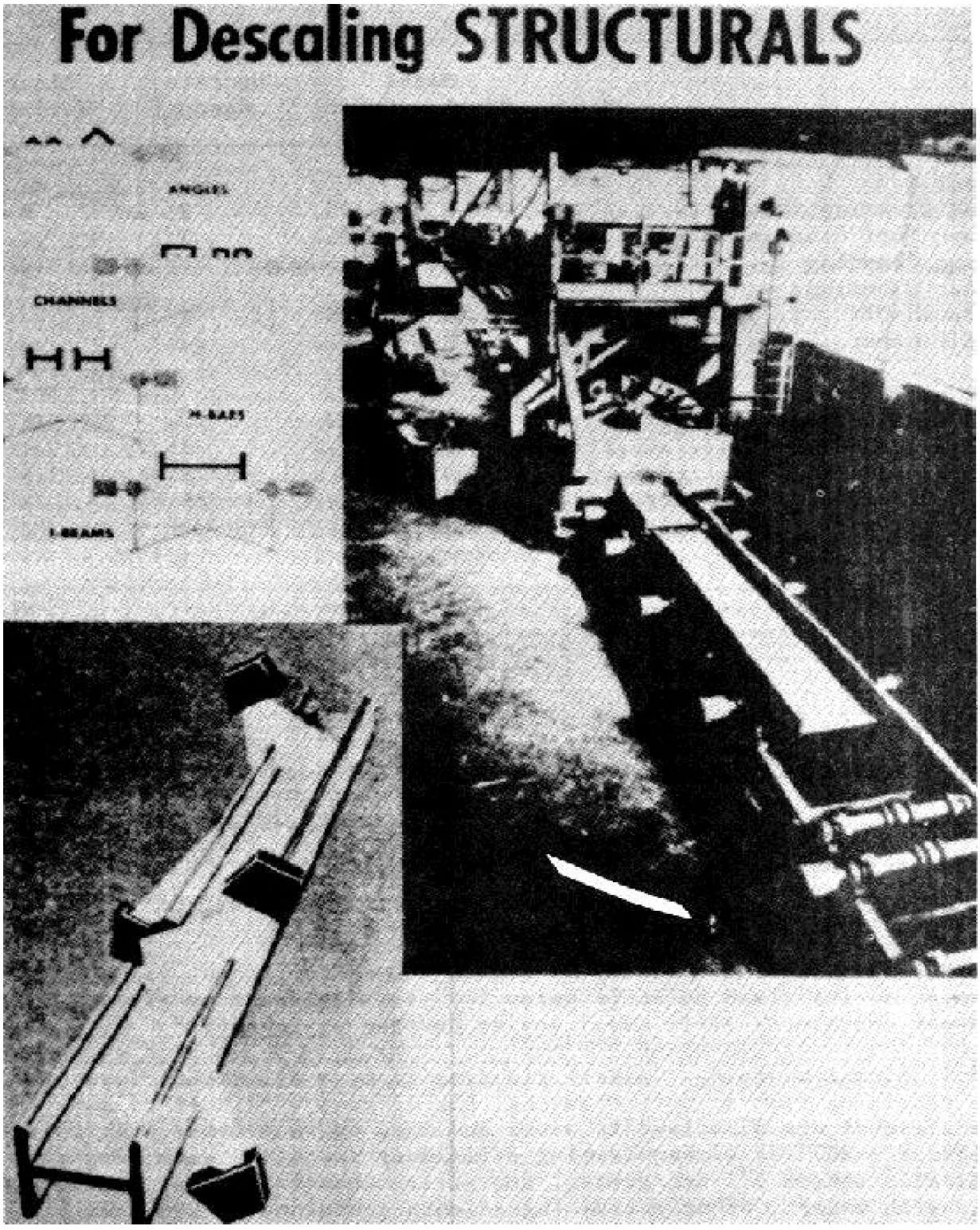


FIGURE 4-19
Centrifugal Blasting

TABLE 4-4
Treatment of Various Substrates

	Wood	Metal Steel	Metal Other	Concrete Masonry	Plaster Wallboard
Mechanical					
Hand Cleaning	S	S	S	S	S
Power Tool Cleaning	S*	S	...	S	...
Flame Cleaning...	...	S	...	...	...
Blast Cleaning:					
Brush-Off	...	S	S	S	...
All Other	...	S	...	...	...
Chemical and solvent					
Solvent Cleaning	S	S	S	...	...
Alkali Cleaning	...	S	...	S	...
Steam Cleaning	...	S	...	S	...
Acid Cleaning	...	S	...	S	...
Pickling	...	S	...	...	...
Pretreatments					
Hot Phosphate	...	S	...	...	...
Cold Phospate	...	S	...	...	...
Wash Primers	...	S	S	...	...
Conditioners, sealers, and fillers					
Conditioners	...	...	...	S	...
Sealers	S	...	...	...	...
Fillers	S	...	...	S	,,,

S--Satisfactory for use as indicated
*--Sanding only

list the flash points and relative toxicity of common solvents. Do not use a solvent for cleaning if its flash point is below 100° F. Rags must be placed in fireproof containers after use. Review Chapter 3, "Safety."

4.4.3.2 Alkali Cleaning. Alkali cleaning is more efficient, less costly, and less hazardous than solvent cleaning, but is more difficult to carry out. Alkaline cleaners are dissolved in water and used at relatively high temperatures (150° F - 200° F) since cleaning efficiency increases with temperature. Alkalis attack oil and grease, converting them into soapy residues that wash away with water. Other active ingredients contained in the alkali cleaners aid in removing surface dirt and other contaminants such as mildew. These cleaners are also effective in removing old paint by saponifying the dried vehicle. The most commonly used alkaline cleaners are trisodium phosphate, caustic soda, and silicated alkalis. They can be applied by brushing,

scrubbing, spraying, or by immersion of the surface into soak tanks. Thorough water rinses are absolutely necessary to remove the soapy residue as well as all traces of alkali and to avoid reactivity with the applied paint. Otherwise, cleaning may do more harm than good. The water should be hot and, preferably, applied under pressure. If used on steel, these cleaners should contain 0.1 percent chromic acid or potassium dichromate to prevent corrosion. Universal pH test paper placed against the wet steel should be used to check for the presence of free alkali after rinsing. Do not use alkali cleaners on aluminum or stainless steel.

4.4.3.3 Steam Cleaning. Steam or hot water under pressure is used in this method of cleaning. A detergent should be included for added effectiveness. The steam or hot water remove oil and grease by liquefying them because of the high temperature, then by emulsifying them and diluting them with water. When used on old paint, the vehicle is swollen so that it loses its adhesiveness and is easily removed. Steam or hot water alone is commonly used to remove heavy dirt deposits, soot, and grime. Wire brushing and/or brush-off blast cleaning may be necessary to augment the steam cleaning process by removing remaining residues.

4.4.3.4 Water Blast Cleaning. High pressure water spray or water blast cleaning cleans through the high velocity impact of water on the surface. The most widely used pressures are 1500 to 3000 psi although pumps are available with much higher pressure capacities. The most widely used water flow rates are 4 to 9 gallons per minute. Detergents may be added to the high pressure water system or the water may be heated to facilitate cleaning. Also, rust inhibitors can be added to inhibit rusting. However, water blast cleaning alone will not remove mill scale from hot rolled steel, readily remove intact paint, nor will it abrade metal surfaces to produce an anchor pattern in the manner of other blast cleaning techniques which impact sand, metal shot, and other abrasive particles on the surface. A useful paint removal technique utilizing water blast cleaning consists of treating the painted surface with a paint stripper, allowing the solvent(s) in the paint stripper to soften the old paint and then applying high pressure water spray to remove the old paint. This process may be repeated as necessary to remove multiple layers of paint. High pressure water spray equipment is available for use at higher water pressures, generally 5,000 to 10,000 psi with abrasive injection into the water stream, which will remove paint and also produce a white metal blast cleaned surface. Because of the high water pressures involved in using this type equipment, operators must be thoroughly trained in safety procedures.

4.4.3.5 Acid Cleaning. This method is used for cleaning iron, steel, concrete, and masonry by treating them with an acid solution.

a. Iron and Steel: These surfaces are treated with solutions of phosphoric acid containing small amounts of solvent, detergent, and wetting agent. (Do not use on aluminum or stainless steel.)

Such cleaning effectively removes oil, grease, dirt, and other foreign contaminants. In addition (and unlike alkali cleaners), it also removes light rust and faintly etches the surface to ensure better adhesion of applied coatings. There are many types of phosphoric acid metal cleaners and rust removers, each formulated to perform a specific cleaning job. There also are

four basic methods of using acid cleaners and each requires a variation in the phosphoric acid concentration as well as a different detergent system. The methods are:

Wash-off: This involves the application of the cleaner, a time allowance for it to act, a thorough rinsing and a drying period before painting.

Wipe-off: This is used when rinsing is impractical and involves the application of the cleaner, a time allowance for it to act, wiping of the surface with clean, damp cloths, final wiping with clean dry cloths, and a drying period prior to painting.

Hot-dip: This involves immersion of the work in hot cleaner, a rinse in hot or cold water after the surface is sufficiently cleaned, a second rinse in weak cleaner solution (5 percent), and a drying time before painting.

Spray: This involves the same steps as with the wash-off method but requires pressurized spray equipment.

b. Concrete and Masonry: These surfaces are washed with 5 to 10 percent muriatic (hydrochloric) acid to remove efflorescence and laitance, to clean the surface, to remove any glaze, and to etch the surface. Efflorescence is a white, powdery, crystalline deposit often found on concrete and masonry surfaces. Laitance is fine cement powder which floats to the surface after concrete is poured. Coatings applied over loose deposits of efflorescence or laitance will loosen prematurely and result in early coating failure. Remove as much of the loose efflorescence or laitance as possible using a clean, dry wire or stiff fiber brush. Putty knives or scrapers may also be used. All oil and grease must also be removed prior to acid cleaning, either by solvent wiping or by steam or alkali cleaning. To acid clean these surfaces, thoroughly wet the surface with clean water, then scrub it with a 5 percent solution (by weight) of muriatic acid, using a stiff fiber brush. In extreme cases, up to a 10 percent muriatic acid solution may be used and may be allowed to remain on the surface up to five minutes before scrubbing. Work should be done on small areas, not greater than 4 square feet in size. Immediately after the surface is scrubbed, wash the acid solution completely from the surface by thoroughly sponging or rinsing with clean water. Rinsing must be done immediately to avoid formation of salts on the surface which are difficult to remove.

The above procedure is also used when it is desired to etch the surface, e.g., to remove the glaze. Often, when concrete surfaces are steel troweled they may become so dense, smooth, and even glazed that paint will not adhere to the surface. A simple method to determine whether etching is required is to pour a few drops of water on the surface. If water is quickly absorbed, etching is unnecessary. In addition to this acid washing, glaze may be removed by rubbing with an abrasive stone, lightly sandblasting, or allowing the surface to weather for 6 to 12 months. It may also be removed by treatment with a solution of 3 percent zinc chloride plus 2 percent phosphoric acid to etch the surface. This is not flushed off but is allowed to dry to produce a paintable surface. It may be necessary, in certain instances, to use acid cleaning methods to neutralize concrete and masonry surfaces before

applying a coating which is sensitive to alkali (see 5.2.2.3). To detect the presence of free alkali, dampen the surface in several spots and apply dampened pH testing paper.

4.4.3.6 Pickling. This method is used in the shop to completely remove all mill scale, rust, and rust scale. Sulfuric, hydrochloric, nitric, hydrofluoric, and phosphoric acid are used individually or in combination. Sulfuric acid is most frequently employed because of its low cost, high boiling point, and general suitability. Pickling is usually accomplished by immersing work in tanks, but the same principles apply if the solution is sprayed or washed over the contaminated surface. Because mill scale itself is not chemically consistent throughout its composition, the outer layer tends to resist the acid solution, but the lower layers (and base metal) are soluble in the acid. Thus, the diluted acid penetrates cracks in the outer scale layer, dissolves some of the scale beneath, penetrates to the lowest layer and base metal to dissolve them rapidly and cause all of the scale to eventually flake off the surface. During this process, any rust or rust scale is dissolved completely in the acid solution, being considerably less resistant to the acid action. Inhibitors are added to the solution to minimize acid action on base metal exposed in those portions of the surface that have cleaned faster than others. Work must be solvent- or alkali-cleaned to remove oil and grease before pickling (pickling will not suitably accomplish this). Following pickling, several rinses are necessary to remove acids and salts with a final rinse in a weak alkali solution to retard rusting. It should be noted that pickling is a low-cost shop procedure, provided there is sufficient work to keep the equipment in regular use. Do not use this method on aluminum or stainless steel. See also SSPC-SP 8.

4.4.3 7 Paint Removers. Paint and varnish removers generally are used for small areas. Solvent type removers or solvent mixtures are selected according to the type and condition of the old finish as well as the nature of the substrate. Removers are available as flammable or nonflammable types, also liquid or semipaste in consistency. While most paint removers require scraping or steel wool to physically remove the softened paint, types are available that allow the loosened finish to be flushed off with steam or hot water. Many of the flammable and nonflammable removers contain paraffin wax to retard evaporation. It is absolutely essential that this residue be removed from the surface prior to painting to prevent loss of adhesion to the applied coating. In such instances, follow the manufacturer's label directions or use mineral spirits to remove any wax residue. As a safety precaution, it should be noted that, while nonflammable removers eliminate fire hazards, they are toxic to a degree (as are all removers). Proper ventilation must be provided whenever they are used.

4.4.3.8 Summary. Chemical methods of surface cleaning are usually more suited to paint shop application while mechanical methods are generally more practical in field work. On the basis of overall effectiveness and efficiency, chemical cleaning is superior to mechanical methods, with the exception of blast cleaning. The paint or paint system selected for any given surface and environment is of primary importance. The coating and environment, then, determine the degree of surface cleaning required. The existing surface conditions, job location, equipment availability, and economic factors will serve as a guide to the cleaning method required. Project specifications also will provide a guide to the recommended cleaning method. In

the case of paint systems, manufacturer's directions will probably be even more specific, including the cleaning methods recommended. See Table 4-4 for a list of substrates and satisfactory cleaning procedures.

4.4.3.9 Precautions. Use goggles and rubber gloves when handling chemical cleaners and protective clothing where acid or alkaline solutions are used. Adequate ventilation is essential. Use respirators when cleaners must be applied in confined areas. Flammable cleaners necessitate that all proper fire precautions be taken. Only experienced personnel will be permitted to perform cleaning by steam, acid, pickling, or other methods that constitute a hazard if mishandled or improperly supervised. Under no circumstances will procedures be followed without full and complete knowledge of the operation. (See Chapter 3.)

4.4.4 PRETREATMENTS. Pretreatments are applied on metal surfaces after cleaning to improve the adhesion and to improve the effectiveness of the applied paint. Refer also to Steel Structures Painting Council Manual No. 2.

4.4.4.1 Hot Phosphate Treatments. Hot phosphate treatments utilize zinc or iron phosphate solutions to form crystalline deposits on the surface of the metal. They greatly increase the bond and adhesion of applied paints while reducing underfilm corrosion. Zinc phosphate generally produces the best results and is most widely used. The hot phosphate solutions are somewhat critical in their application and require carefully controlled conditions and cleaned surfaces. As these deposits thicken, the system becomes more brittle. However, adhesion increases and rust prevention is more effective. When painting, it usually is necessary to apply thicker paint coats over the heavier phosphate coatings if a gloss finish is desired, because the heavier phosphate coatings absorb considerably more paint. If a higher gloss finish is desired, iron phosphate is preferred to the zinc phosphate pretreatment, because it produces a finer crystalline structure and hence a thinner film. The hot phosphate treatments are excellent procedures leading to tight bonds between the surface and applied paint. The mechanics of hot phosphate treatment limit its use to the paint shop. See also SSPC-PT 4.

4.4.4.2 Cold Phosphate Treatments. These treatments are produced with a mixture of phosphoric acid, wetting agent, water miscible solvent and water. An acid concentration of about 5 to 7 percent (by weight) will produce the desired reaction with steel when the area to be treated is not exposed to high summer temperatures, direct sunlight, or high wind velocities. Such environmental conditions cause rapid evaporation and consequent high acid concentration. When a dry, powdery surface, grayish-white in color, develops within a few minutes after application, the acid has reacted properly and has the proper dilution. If a dark color develops and the surface is somewhat sticky, the acid is too concentrated. In such cases, if the area is small, wiping with damp rags may bring about the desired appearance. Otherwise, rinse the surface with water and re-treat with a more dilute solution. Although cold phosphate treatments produce a crystalline deposit on the metal surface, the density of the deposit is not as great as the hot phosphate treatment; therefore, paint adhesion is not quite as good. The procedures used for cold phosphating are adaptable to field use on large or small structures. See also SSPC-PT 2.

4.4.4.3 Wash Primers. Wash primers are actually a form of cold phosphatizing. They perform more efficiently than the standard cold phosphating treatments and are generally replacing them for field use. Wash primers are so called, because they are applied in very thin or "wash" coats. They contain polyvinyl butyral resin, phosphoric acid, and a rust inhibitive pigment such as basic zinc chromate or lead chromate. Wash primers develop extremely good adhesion to blast cleaned or pickled steel and provide a sound base for topcoating. They are also used to promote adhesion of coatings to surfaces generally considered difficult to paint, such as galvanized or stainless steel and aluminum.

4.4.4.4 Chemical Conversion. Coatings. The chemical conversion coatings are chromate conversion coatings. These coatings are specifically formulated for aluminum, magnesium, zinc, cadmium, copper, and silver to prevent or retard corrosion and when required to provide a good base on which to apply primer and finish coats. The coatings impart a light iridescent gold to light green color to the white metals, when properly applied. When this treatment is to be applied to aluminum, the surface should be alkaline etched and the coating applied by brush or dip until the appropriate color is obtained as described in MIL-C-5541. The reaction may be stopped by water rinsing the excess chemical from the surface. Care should be exercised to prevent splashing this toxic chemical on one's skin! Materials suitable for producing chromate conversion coatings conform to MIL-C-81706.

4.4.5 CONDITIONERS, SEALERS, AND FILLERS. Conditioners are often applied on masonry to seal a chalky surface in order to improve adhesion of water-based topcoats. Sealers are used on wood to prevent resin exudation or bleeding. Fillers are used to produce a smooth finish on open grain wood and rough masonry. (See Table 4-4.)

4.4.5.1 Conditioners. Latex (water-thinned) paints do not adhere well to chalky masonry surfaces. To overcome this problem, an oil-based conditioner is applied to the chalky substrate before the latex paint is applied. The entire surface should be vigorously wire brushed by hand or power tools, then dusted to remove all loose particles and chalk residue. The conditioner is then brushed on freely to assure effective penetration and allowed to dry. This surface conditioner is not intended for use as a finish coat.

4.4.5.2 Knot Sealers. Sealers are used on bare wood to prevent resin exudation (bleeding) through applied paint coatings. Freshly exuded resin, while still soft, may be scraped off with a putty knife and the affected area solvent cleaned with alcohol. Hardened resin may be removed by scraping or sanding. Since the sealer is not intended for use as a priming coat, it should be used only when necessary, and applied only over the affected area. When previous paint on pine lumber has become discolored over knots, the sealer should be applied over the old paint before the new paint is applied.

4.4.5.3 Fillers. Fillers are used on porous wood, concrete, and masonry to fill the pores to provide a smoother finish coat.

a. Wood Fillers: Wood filters are used on open-grained hardwoods. In general those hardwoods with pores larger than in birch should be filled.

TABLE 4-5
Characteristics of Wood

Name of wood	Type Grain	Soft Closed	Soft Open	Hard Closed	Notes on Finishing
Ash		...	X	...	Requires filler.
Alder		X	...	...	Stains well.
		...	...	X	Paints well.
Basswood		...	...	X	Paints well.
Beech		...	...	X	Paints poorly; varnishes well.
Birch		...	...	X	Paints and varnishes well.
Cedar		X	...	...	Paints and varnishes well.
Cherry		...	...	X	Varnishes well.
Chestnut		...	X	...	Requires filler; paints poorly.
Cottonwood		...	...	X	Paints well.
Cypress		...	...	X	Paints and varnishes well.
Elm		...	X	...	Requires filler; paints poorly.
Fir		X	...	...	Paints poorly.
Gum		...	...	X	Varnishes well.
Hemlock		X	...	...	Paints fairly well.
Hickory		...	X	...	Requires filler.
Mahogany		...	X	...	Requires filler.
Maple		...	...	X	Varnishes well.
Oak		...	X	...	Requires filler.
Pine		X	...	...	Variable depending on grain.
Teak		...	X	...	Requires filler.
Walnut		...	X	...	Requires filler.
Redwood		X	...	...	Paints well.

Note: Any type finish may be applied unless otherwise specified.

(See Table 4-5.) When filling is necessary, it is done after any staining operations. Stain should be allowed to dry for 24 hours before filler is applied. If staining is not warranted, natural (uncolored) filler is applied directly to the bare wood. The filler may be colored with some of the stain in order to accentuate the grain pattern of the wood. To apply, first thin the filler with mineral spirits to a creamy consistency, then liberally brush it across the grain, followed by light brushing along the grain. Allow to stand 5 to 10 minutes until most of the thinner has evaporated, at which time the finish will have lost its glossy appearance. Before it has a chance to set and harden, wipe the filler off across the grain using burlap or other coarse cloth, rubbing the filler into the pores of the wood while removing the excess. Finish by stroking along the grain with clean rags. It is essential that all excess filler be removed. Knowing when to start wiping is important; wiping too soon will pull the filler out of the pores, while allowing the filler to set too long will make it very difficult to wipe off. A simple test for dryness consists of rubbing a finger across the surface. If a ball is formed, it is time to wipe. If the filler slips under the pressure of the finger, it is still too wet for wiping. Allow the filler to dry for 24 hours before applying finish coats.

b. Masonry Fillers: Masonry fillers are intended for use on porous surfaces as rough concrete, concrete block, stucco, and other masonry surfaces. The purpose of the filler is to fill the open pores and voids by brushing the filler into. the surface to produce a fairly smooth finish suitable for painting. There are two types of filler coatings: one a solvent-thinned material, i.e., TT-F-1098, which cannot be applied to damp masonry, and the other a water-thinned cementitious or latex emulsion coating (see TT-P-19, section 5.1.1) which can be applied to damp masonry. Before using fillers, the surfaces must be clean, whether they are new, old or have been previously painted. On previously painted surfaces, only the solvent-type filler should be used. Uncoated surfaces should be prepared as described in 4.4.3.4.b. Residual form oil or other organic material on the surface should be removed by sandblasting, or strong detergent treatment, including proper rinsing, or if time permits, allowing natural weathering to remove the oils. On previously painted surfaces, all loose, powdery, or flaking material, dirt, and old paint may be removed effectively by sand-blasting. Application of either type coatings should be at ambient temperatures of 50° F or higher. Allow the filler to dry for 24 hours before painting. When applying a cement-water or emulsion-type filler, a brush with relatively short bristles, for example, Tampico fiber, is needed to work the filler into the voids. Solvent-thinned filler may be applied by brush, roller or spray; however, a brush is preferred to most effectively work the material into the pores. Before this filler becomes tacky, usually 3 to 5 minutes, excess material is removed with a rubber squeegee. The moderate pressure exerted using the squeegee helps to fill the voids and smooth the surface besides removing excess filler.

4.4.6 APPLICABLE SPECIFICATIONS. The specified products which are recommended for surface preparation before painting are listed in Appendix D-l, Table 1.

Section 5. REPAIR OF SURFACES

4.5.1 GENERAL. All surfaces must be in good condition before painting. Repair or replace degraded wood, concrete, masonry, stucco, metal, plaster and wallboard. Remove and replace all loose mortar in brickwork. Replace broken windows and loose putty or glazing compound. Securely fasten or replace loose gutter hangers and downspout bands. Fill all cracks, crevices, and joints with calking compound, or sealants. Drive all exposed nail heads below the surface. Patch all cracks or holes in wood, masonry and plaster. The final surface should be smooth, with no openings or defects of any kind. These preparatory procedures eliminate the major areas for the entrance of moisture which can lead to blistering and peeling of the paint film.

4.5.2 CALKING COMPOUNDS AND SEALANTS. Calking compounds are oil and/or resin based. They are used in fixed joints of wood, metal, or masonry, also in joints of wood, metal, or masonry, also in joints with very limited movement. Sealants, on the other hand, are elastomeric, rubber-like compounds. They are intended for use in expansion or other movable joints. Sealants are available as one or two component compounds.

4.5.2.1 Calking Compounds. Calking compounds are used to fill joints and crevices around doors and windows in wood, brick, concrete, and other masonry surfaces. They are supplied in two grades: a gun grade and a knife grade. The gun grade is most popular since it is easier to use and faster in application because it employs the use of a calking gun, whereas the knife

grade must be applied by hand using a putty knife. The gun grade is supplied in two forms, i.e., in bulk and in factory prefilled cartridges. The cartridge type fits directly into a calking gun and is preferred for convenience of use. Triggering the gun extrudes the calking compound directly into the crevice. A variety of different shaped tips aid in speeding up the work. Calking compounds tend to dry on the surface but remain soft and tacky within the crevice. The applied calking should be painted each time the surrounding area is painted to help extend its life.

4.5.2.2 Sealants. Sealants are an advanced and much more durable type of calking compound. Compared with calking compounds, they have better adhesion to the walls of the crevices, have better extensibility so that they do not pull away when the walls contract in cold weather, and they remain flexible for much longer periods of time. Although they are considerably more expensive than calking compounds, their longer life is often well worth the difference in cost. There are many types of sealants, and they may be divided into three groups:

a. One Component: These are similar to calking compounds in general handling. All are available in bulk and some are also available in cartridges. They are applied in a manner similar to calking compounds.

b. Two Component: These are supplied only in bulk since they must be premixed before use. Their useful, or pot-life when mixed, is normally, not less than 3 hours. High temperatures may drastically shorten this time. The two components react to form a tough rubbery seal with excellent adhesion, extensibility and durability.

c. Preformed Tapes: These sealants are supplied in an extruded bead so that they can be applied simply by pressing the tape into crevices by hand without the use of tools.

4.5.3 PUTTY. Putty is used to fill nail holes, cracks, and imperfections in wood surfaces. It is supplied in bulk form and is applied with a putty knife. Putty is not flexible and should not be used for joints and crevices. It dries to a harder surface than calking compound.

4.5.4 GLAZING COMPOUND. Glazing compounds are used on both interior and exterior wood and metal window sash either as bedding or face glazing. They are used to cushion glass in metal or wood frames and are not intended to keep or hold the glass in position. Glazing compounds set firmly, but not hard, and have some limited flexibility. They are more flexible than putty. They tend to harden upon exposure with life expectancy estimated to be approximately 10 years, if they are properly applied. Painting over glazing compounds will extend their useful life. Glazing compounds are relatively inexpensive though more costly than putty.

4.5.5 APPLICATION OF CALKING AND GLAZING COMPOUNDS, PUTTY, AND SEALANTS. All surfaces must be clean and dry to obtain good adhesion. Remove all oil, grease, soot, dirt, loose paint, or old materials. Be sure the crevice openings are large enough to allow an adequate amount of material to be inserted. Prime substrate, when recommended by the manufacturer, in accordance with directions given. If the opening is deep, first insert back-up materials such as oakum, foamed plastic or rubber, fiberglass, or fiberboard.

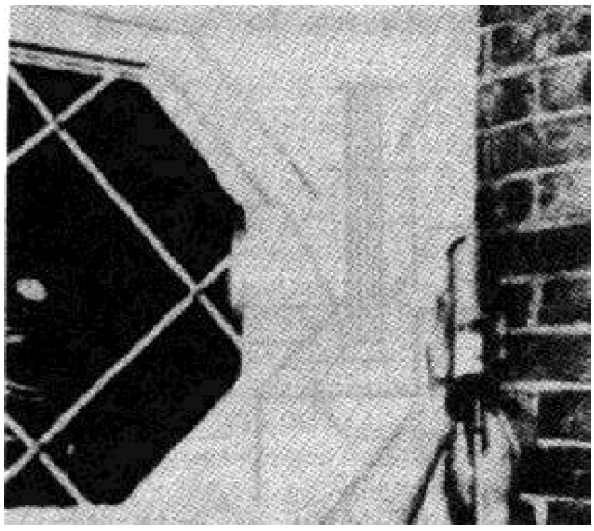


FIGURE 4-20
Calking

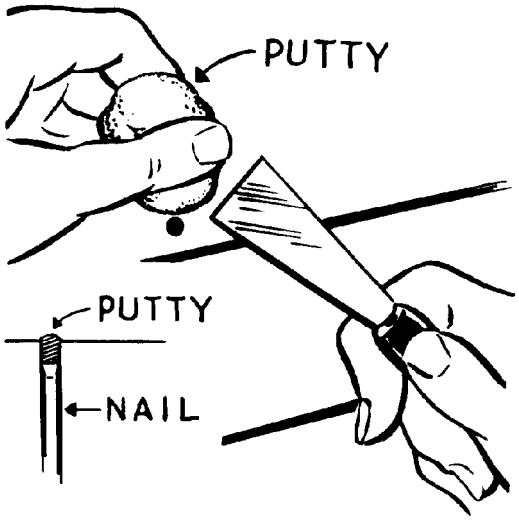
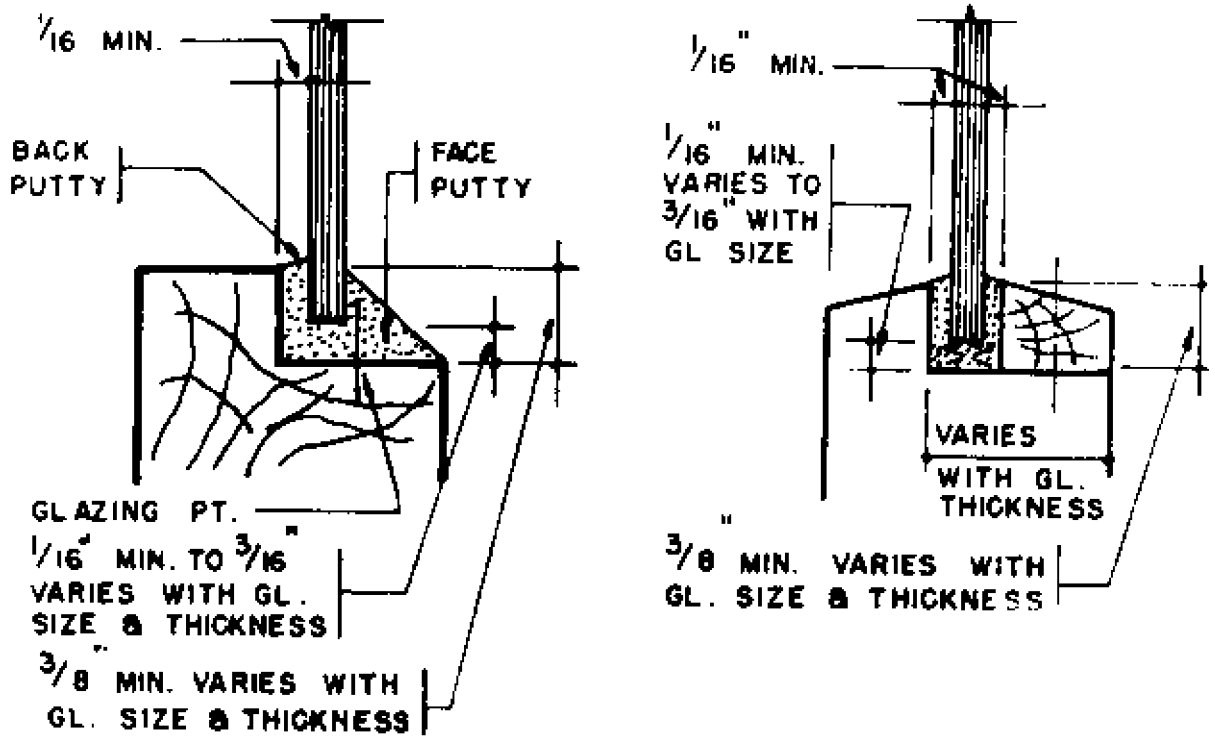


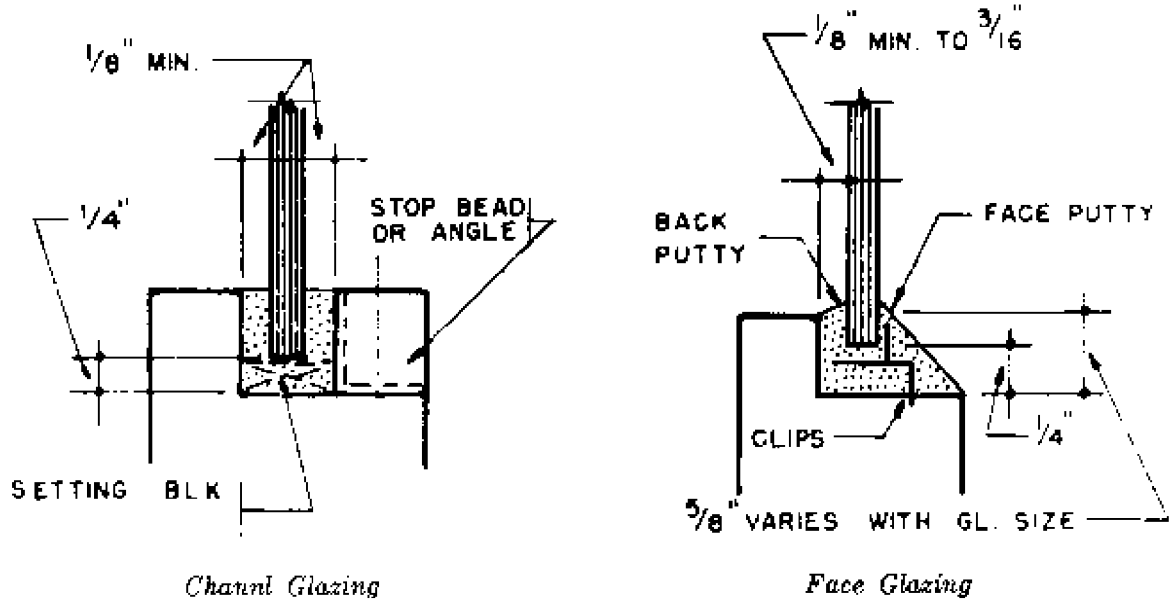
FIGURE 4-21
Puttying

Covering nail heads with putty, after priming coat has dried. The putty should be squeezed into the nail hole and cut off with a putty knife while under pressure. The surface of the putty should be slightly convex to allow for shrinkage, as shown in the detail.



Face Glazing *Channel Glazing*

FIGURE 4-22
Glazing--Wood Frames



Channl Glazing *Face Glazing*

FIGURE 4-23
Glazing--Metal Frames

4.5.5.1 Gun Grade Calking Compounds and Sealants. When applying gun grade material, move the gun along the crevice while triggering so that the compound is extruded directly into the crevice. Move the gun slowly and steadily, so as to push the bead into the crevice rather than pull it away. Allow the compound to overlap the opening slightly for a better seal, and to allow sufficient surface area for adhesion. The best position to hold the gun is at a slight angle with the bevel parallel to the work. (See Figure 4-20.) Compound should finally be tooled to insure close contact with the joint surfaces.

4.5.5.2 Knife Grade Calking Compounds, Sealants, and Putty. When applying knife grade material or putty, use a putty knife and press firmly into cracks or holes until full. Then smooth with the flat side of the knife by sliding it across the surface. The exposed area should be slightly convex to allow for shrinkage. (See Figure 4-21.)

4.5.5.3 Face Glazing. For face glazing, apply a generous quantity of glazing compound into the glazing rabbet, and gently press the glass into the rabbet, leaving a bed of back glazing material of approximately 1/16 inch. Apply glazing points to hold the glass in place. Strip surplus glazing compound at an angle to allow for run-off of condensation. Apply additional glazing compound to the face and tool into place with the aid of a putty knife, applying sufficient pressure to completely fill the void. Tool face glazing approximately 1/16 inch short of sight line to allow paint to overlap onto glass. (See Figures 4-22 and 4-23.)

4.5.5.4 Channel Glazing. For bead or channel glazing, apply a generous amount of the compound to the fixed (stationary) side and the bottom of the channel. Place nonporous resilient spacer shims (such as vinyl floor tile)

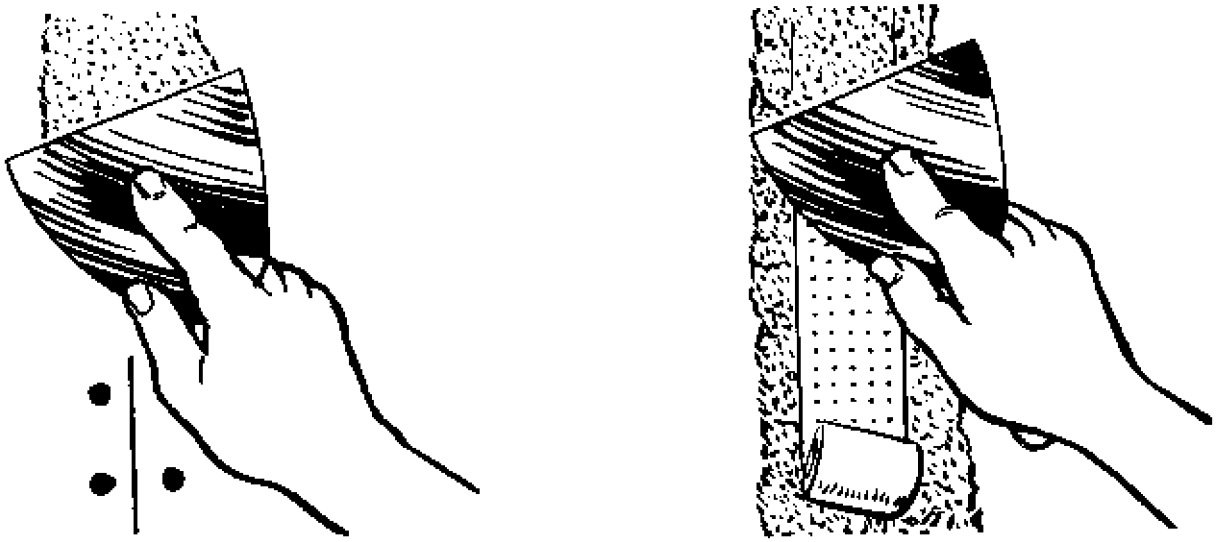
at points around the perimeter of the channel to position glass and prevent squeezing out of compound (keep spacer shims below edge of channel). Press glass into place until intimate contact with spacer shims is made. Spread compound on removable bead and gently press into place. Insert spacer shims between glass and removable bead (opposite spacer shims on fixed side of the channel) and apply pressure to removable bead until intimate contact with spacer shims is made. Fasten bead in place and strip excess compound. When glazing compound has attained a surface skin, apply paint, slightly overlapping the sight line. (See Figures 4-22 and 4-23.)

4.5.6 PATCHING MATERIALS. Cracks, holes, and crevices in masonry, plaster, wallboard, and wood are filled with patching material. It is supplied either ready for use or as a dry powder to which water is added before use. There are a variety of types depending on the surface and its conditions.

4.5.6.1 Patching Plaster. This is used for repairing large areas of plaster. It is similar to ordinary plaster except that it hardens quickly. It is supplied as a powder.

4.5.6.2 Spackle. Spackling compound is used to fill cracks and small holes in plaster and wallboard. It is very easy to work with and sands very well after it hardens. It is supplied both as a paste and as a powder.

4.5.6.3 Joint Cement. This is used primarily to seal the joints between wallboards. It can also be used to repair large cracks. It is supplied as a powder and is used in conjunction with perforated tape which gives it added strength. (See Figure 4-24).



Covering joint between pieces of wallboard with perforated tape. Left. Filling joint and covering nail heads. Right. Embedding tape in cement.

FIGURE 4-24
Applying Joint Cement

4.5.6.4 Portland Cement Grout. This is used to repair cracks in concrete and masonry. Hydrated lime is often added to slow up its cure time and lengthen its working life.

4.5.6.5 Plastic Wood. Plastic wood is a filler suitable for such repair work as filling gouges and nail holes. It is also used for building up and filling in wood patterns and joiner work. It is applied in a manner similar to putty. Sand plastic wood smooth after it has completely dried and before applying paint.

4.5.6.6 Application of Patching Materials. When using any of the above patching materials (except plastic wood) on masonry, plaster, or wallboard, the crack should first be opened with a putty knife or wall scraper so that weak material is removed and the patching compound can be forced in completely. Dampen these areas with clear water and apply the compound with a putty knife or trowel depending on the size of the hole. Level and smooth off the surface allowing it to be slightly convex to allow for shrinkage. Follow manufacturer's instructions explicitly if they are available. None of these materials requires attention during drying, except for the Portland cement grout which should be kept damp at least 1, and preferably 2 or 3 days for optimum care. When the surface is dry and hard, sand it (except Portland cement) until it is smooth and level with the surrounding area.

4.5.7 APPLICABLE SPECIFICATIONS. The products which are specified for surface preparation and repair before painting are listed in Appendix D-l, Tables 1 and 2.

Section 6. PAINT APPLICATION

4.6.1 GENERAL. The most common methods of applying paint are by brush, roller, and spray. Dip and flow coat methods are also used but the mechanics of application limit their use to shop work. Of the three designed for field use, brushing is the slowest method, rolling is much faster, and spraying is usually the fastest of all. The choice of method is based on many additional factors such as environment, type of substrate, type of coating to be applied, appearance of finish desired, and skill of personnel involved in the operation.

4.6.1.1 Environment. General surroundings may prohibit the use of spray application because of possible fire hazards or potential damage from overspray. Typical of these are parking lots and open storage areas. Adjacent areas, not to be coated, must be masked when spraying is performed. This results in loss of time and, if extensive, may offset the advantage of the rapidity of spraying operations. The use of dropcloths is essential both for the protection of floors, furniture equipment, etc., during interior paint application and for the protection of shrubbery, equipment, etc., during exterior paint application. In addition to the cotton fabrics usually used for this purpose, dropcloths may be of a special paper impregnated with a wax or resin, vinyl sheeting, or polyethylene rolls. In ordinary use, fabric dropcloths may be laundered many times and many industrial laundries provide this service. The lighter paper and plastic dropcloths are both easily disposable and reusable. In cases where mastics are being applied or where heavy overspray is anticipated, it may be convenient to use the less expensive dropcloths and dispose after use.

4.6.1.2 Type of Surface. Roller coating is more efficient on large flat surfaces. However, corners, edges, and odd shapes must be brushed. Spraying is most suitable for large surfaces, except that it can also be used for round or irregular shapes. Brushing is ideal for small surfaces or for cutting in corners and edges. Dip and flow coat methods are suitable for volume production painting of small items in the shop.

4.6.1.3 Type of Coating. Rapid drying, lacquer type products, e.g., vinyls, should be sprayed. Application of such products by brush or roller may be extremely difficult especially in warm weather or outdoors on breezy days.

4.6.1.4 Appearance of Finish. Coatings applied by brush may leave brush marks in the dried film; rolling leaves a stippled effect, while spraying yields the smoothest finish, if done properly.

4.6.1.5 Skill of Painting Personnel. Personnel require the least amount of training to use rollers and the most training to use spray equipment. The degree of training and experience of personnel will influence the selection of the application method.

4.6.2 BASIC APPLICATION PROCEDURES. To obtain optimum performance from a coating, there are certain basic application procedures which must be followed, regardless of the type of equipment selected for applying the paint. Cleaned, pretreated surfaces must be first-coated within the specific time limits established. It is essential that surface and ambient t tempera-tures are between 50° F and 90° F for water-thinned coatings and 45° F to 95° F for other coatings, unless the manufacturer specifies otherwise. The paint material should be maintained at a temperature of 65° F to 85° F at all times. Paint is not to be applied when the temperature is expected to drop to freezing before the paint has dried. Wind velocity should be below 15 miles per hour and relative humidity below 80 percent. Masonry surfaces that are damp (not wet) may be painted with latex or cementitious paints. Otherwise, the surface must be completely dry before painting. Paints should be applied at recommended spreading rates. When successive coats of the same paint are used, each coat should be tinted differently to aid in determining proper application and to ensure complete coverage. Sufficient time must be allowed for each coat to dry thoroughly before topcoating. Allow the final coat to dry for as long as is practical before service is resumed.

4.6.3 BRUSH APPLICATION.

4.6.3.1 Equipment. Brushes, as any other tools, must be of first quality and maintained in perfect working condition at all times. Brushes are identified, first, by the type of bristle used. Brushes are made with either natural, synthetic, or mixed bristles. Chinese hog bristles represent the finest of the natural bristles because of their length, durability, and resiliency. Hog bristle has one unique characteristic in that the bristle end forks out like a tree branch. This "flagging" permits more paint to be carried on the brush and leaves finer brush marks on the applied coating which flow together more readily resulting in a smoother finish. Horsehair bristles are used in cheap brushes and are a very unsatisfactory substitute. The ends do not flag, the bristles quickly become limp, they hold far less paint and do not spread it as well. Brush marks left in the applied coating tend to be coarse and do not level out as smoothly. Some brushes contain a

mixture of hog bristle and horsehair and their quality depends upon the percentage of each type used. Animal hair is utilized in very fine brushes for special purposes. Badger hair, for example, produces a particularly good varnish brush. Squirrel and sable are ideal for striping, lining, lettering, and free-hand art brushes. Of the synthetics, nylon is by far the most common. By artificially "exploding" the ends and kinking the fibres, manufacturers have increased the paint load nylon can carry and have reduced the coarseness of brush marks. Nylon is steadily replacing hog bristle because of the difficulties in importing the latter. Nylon is almost always superior to horsehair. The very fact that nylon is a synthetic makes it unsuitable for applying lacquer, shellac, many creosote products, and some other coatings that would soften or dissolve the bristles. Because water does not cause any appreciable swelling of nylon bristles, they are especially recommended for use with latex paints. Brushes are further identified by types, that is, the variety of shapes and sizes as are required for specific painting jobs. Types (See Figures 4-25 and 4-26) can be classified as follows:

a. Wall Brushes: Flat, square-edged brushes ranging in widths from 3 to 6 inches and used for painting large, continuous surfaces, either interior or exterior.

b. Sash and Trim Brushes: Available in four shapes, flat square-edged, flat angle-edged, round, and oval. These brushes range in widths from 1 1/2 to 3 inches or diameters of 1/2 or 2 inches and are used for painting window frames, sash, narrow boards, and interior and exterior trim surfaces. For fine-line painting, the edge of the brush is often chisel-shaped to make precise edging easier to accomplish.

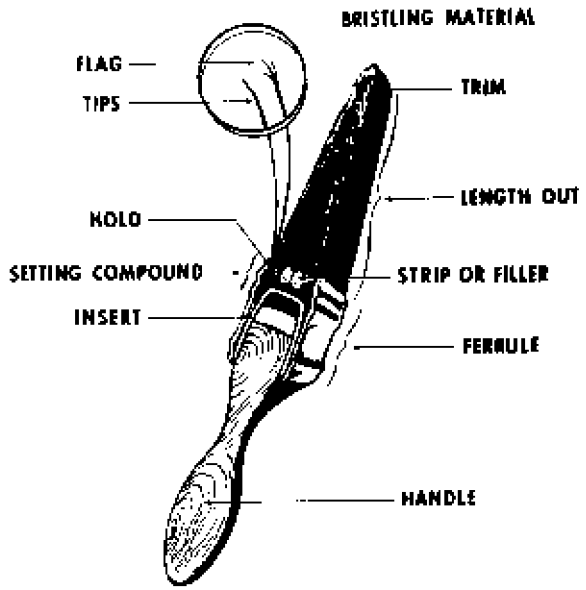


FIGURE 4-25
Typical Paint Brush

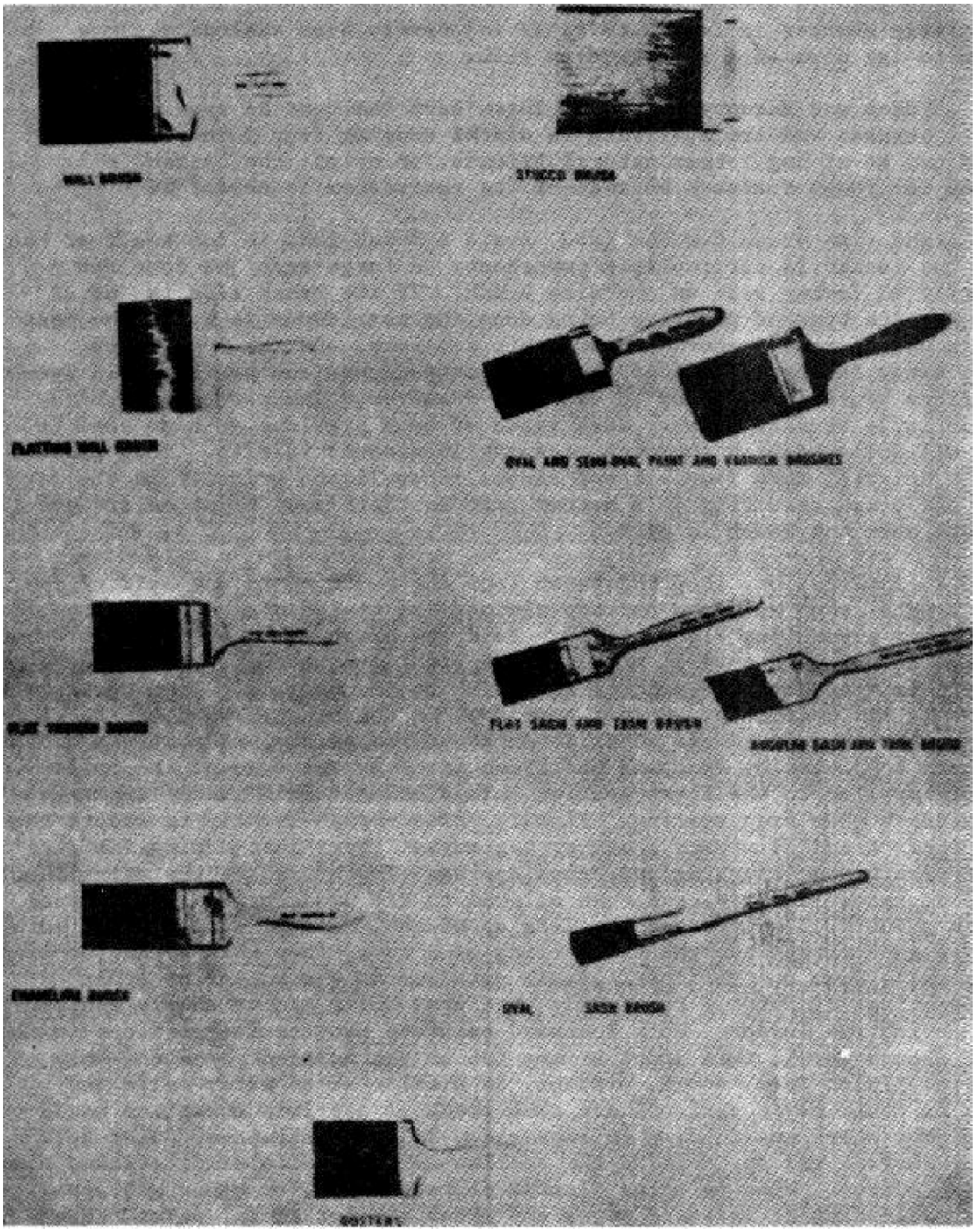


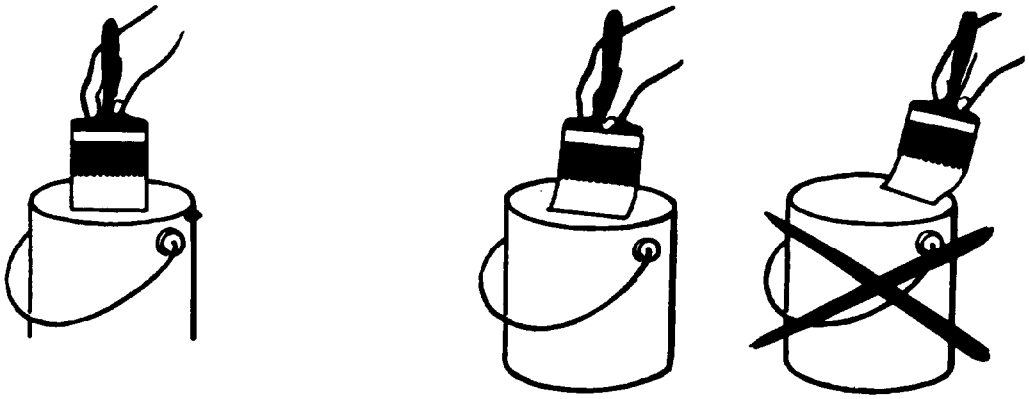
FIGURE 4-26
Types of Brushes

c. Enameling and Varnish Brushes: Flat square-edged or chisel-edged brushes available in widths from 2 to 3 inches. The select, fine bristles are comparatively shorter in length to cause relatively high viscosity gloss finishes to lay down in a smooth, even film.

d. Stucco and Masonry Brushes: These have the general appearance of flat wall brushes and are available in widths ranging from 5 to 6 inches. Bristles can be of hog, other natural bristle, or nylon; the latter is preferred for rough surfaces because of its resistance to abrasion.

Use the right size brush for the job. Avoid a brush that is too small or too large. The latter is particularly important. A large-area job does not necessarily go faster with an oversize brush. If the brush size is out of balance for the type of painting being done, the user tends to apply the coating at an uneven rate, general workmanship declines, and the applicator actually tires faster because of the extra output required per stroke. Synthetic fibre brushes are ready to use when received. The performance of natural bristle brushes is very much improved by a previous 48-hour soak in linseed oil followed by a thorough cleaning in mineral spirits. This process makes the bristles more flexible and serves to swell the bristles in the ferrule of the brush resulting in a better grip so that fewer bristles are apt to work loose when the brush is used.

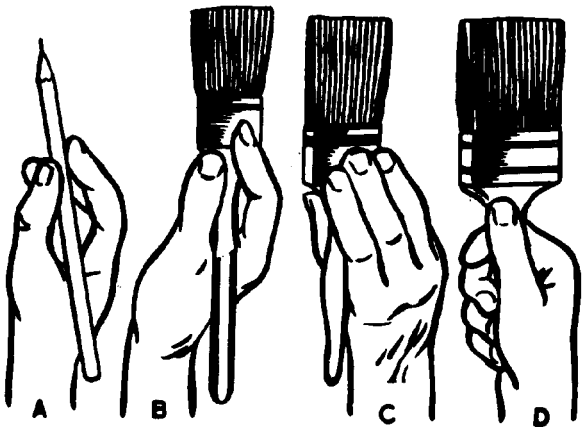
4.6.3.2 Application. Dip the brush into the paint up to one-half of the bristle length, then withdraw and tap against the inside of the bucket to remove excess paint (See Figure 4-27). Hold the brush at an angle of 450 to the work. (See Figure 4-28.) Make several light strokes in the area to be painted; this will transfer much of the paint to the surface. Then spread the paint evenly and uniformly. Do not bear down on the brush. When one section of the surface is painted, adjacent areas should be painted so that the brush strokes are completed by sweeping the brush into the wet edge of the paint previously applied to the first section. This helps to eliminate lap marks and provides a more even coating. Finally, cross-brush lightly to smooth the painted surface and eliminate brush or sag marks. Very fast-drying finishes will not permit much brushing and crosslapping. In such cases the paint should be applied, spread rapidly, and then allowed to dry undisturbed. To go back over such paint will only cause a piling up of the coating. Start major work on topmost area first, such as the ceiling of a room, then work downward, painting walls down to the floor. begin painting at the corner or other logical vertical division. Cover only that area which can be easily reached without moving the ladder. Work downward painting progressive sections to the floor or ground level, then start at the top of the adjacent area and work down again. Paint trim, doors, windows, or similar areas after walls and ceilings or other major surfaces are completed. A possible exception would be painting jobs where scaffolding is required. In such instances, paint both the major surface and any trim in the section as the scaffolding is moved along from area to area. When painting clapboards, mouldings, or other surfaces with narrow leading or indented edges and other similar areas, paint these first and then paint the surrounding continuous surfaces. Corners and edges are always painted so that the stroke is completed by sweeping off the corner or edge. Avoid poking the brush into corners or crevices. Instead, use the edge of the brush and twist it slightly if necessary to cover rough surfaces.



Paint brush bristles should not be dipped into the paint more than half the length of the bristles.

Excess paint should be removed from brush by gently tapping against side of can as shown at left, and NOT by wiping brush across top of can as shown at the right.

FIGURE 4-27
Loading a Paint Brush



A, B. Grasping brush with pencil grip. C. Grip used for painting walls and floors. D. Simple grip with all fingers around brush handle, suitable for use when painting ceilings.

FIGURE 4-28
Holding a Paint Brush

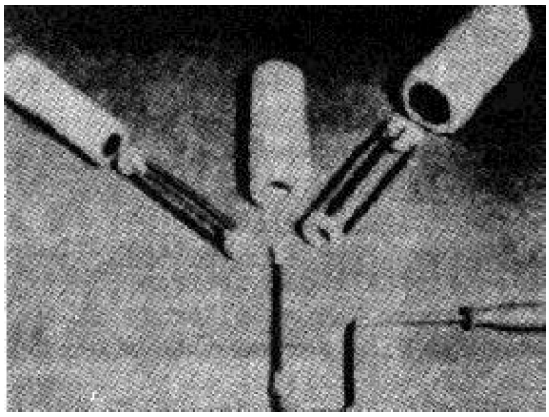


FIGURE 4-29
Parts of a Roller

4.6.4 ROLLER APPLICATION

4.6.4.1 Equipment. A paint roller consists of a cylindrical sleeve or cover which slips on to a rotatable cage to which a handle is attached. (See Figure 4-29.) The cover may be 1 1/2 to 2 1/4 inches inside diameter, and usually 3, 4, 7, and 9 inches in length. Special rollers are available in lengths from 1 1/2 to 18 inches. Proper roller application depends on the selection of the specific fabric and the thickness of fabric (nap length) based on the type of paint used and the smoothness or roughness of the surface to be painted. Special rollers are used for painting pipes, fences and other hard-to-reach areas. Pressure roller equipment is also available. The pressurized paint flow into the roller is controlled by valve. The pressure roller equipment is available for paint stripping and for general paint application. (See Figures 4-30 and 4-31.) The fabrics generally used are as follows:

a. Lambs Wool (pelt): This is the most solvent resistant type of material used and is available in nap lengths up to 1 1/4 inches. It is recommended for synthetic finishes for application on semi-smooth and rough surfaces. It mats badly in water and is not recommended for water paints.

b. Mohair: This is made primarily of Angora hair. It also is solvent resistant and is supplied in 3/16- and 1/4-inch nap length. It is recommended for synthetic enamels and for use on smooth surfaces. It can be used with water paints also.

c. Dynel: This is a modified acrylic fibre which has excellent resistance to water. It is best for application of conventional water paints and solvent paints, except those which contain strong solvents, such as ketones. It is available in all nap lengths from 1/4 to 1 1/4 inches.

d. Dacron: This is a synthetic fibre which is somewhat softer than Dynel. It is best suited for exterior oil or latex paints. It is available in nap lengths from 5/16 to 1/2 inch.

e. Rayon: This fabric is not recommended because of the poor results generally obtained from its use. Furthermore, rayon mats badly in water.

Table 4-6 can be used as a guide for choosing the proper roller cover.

4.6.4.2 Application. Pour the premixed paint into the tray to about one-half of the depth of the tray. Immerse the roller completely, then roll it back and forth along the ramp to fill the cover completely and remove any excess paint. As an alternative to using the tray, place a specially designed galvanized wire screen into a 5-gallon can of the paint. This screen attaches to the can and remains at the correct angle for loading and spreading paint on the roller. (See Figures 4-32 and 4-33.) The first load of paint on a roller should be worked out on newspaper to remove entrapped air from the roller cover. It is then ready for application. As the roller is passed over a surface, thousands of tiny fibres continually compress and expand, metering out the coating and wetting the surface. This is in sharp contrast to other application methods that depend upon the skill and technique of the painter. The uniformity of application by roller is less susceptible to variance in painter ability than other methods. Basic rules must still be followed. Always trim around ceilings, mouldings, etc., before

rolling the major wall or ceiling surfaces. Then roll as close as possible to maintain the same texture. Trimming is usually done with a 3-inch wall brush. Always roll paint onto the surface, working from the dry area into the area just painted. Never roll completely in the same direction. Avoid rolling too fast and spinning the roller at the end of the stroke. Always feather out final strokes to pick up any excess paint on the surface. This is accomplished by rolling the final stroke out with minimal pressure.

4.6.5 SPRAY APPLICATION

4.6.5.1 Equipment. Spray equipment is available in four general types. (See Figures 4-34 and 4-35.)

a. Conventional Spray: The coating material is placed in a closed container called a pot. The introduction of pressurized air from a compressor forces the material through a hose to the spray gun. (See Figures 4-36 and 4-37.) The gun is also connected to a separate air hose. At the gun, the

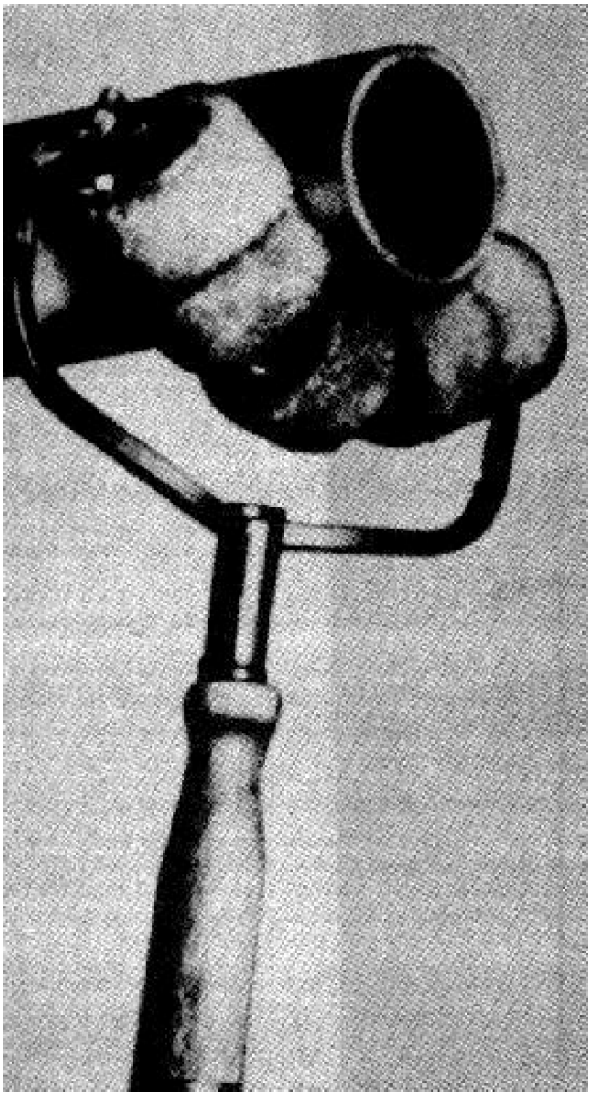


FIGURE 4-30
Pipe Roller

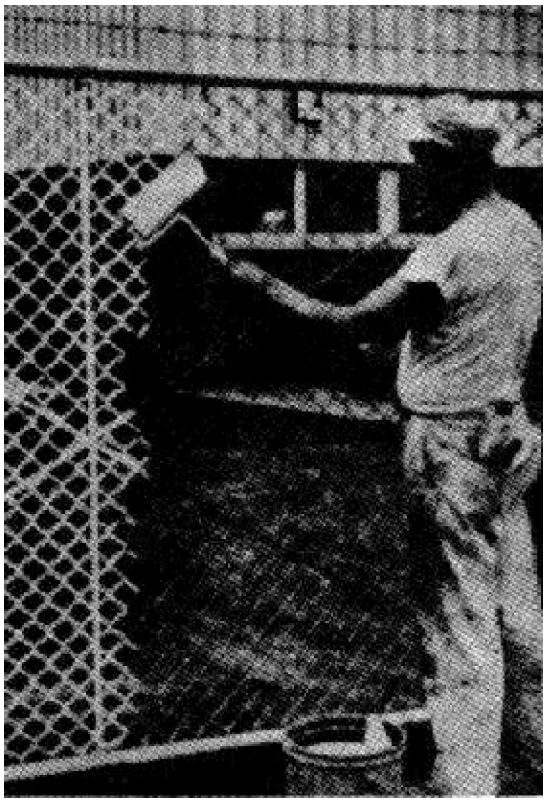


FIGURE 4-31
Fence Roller

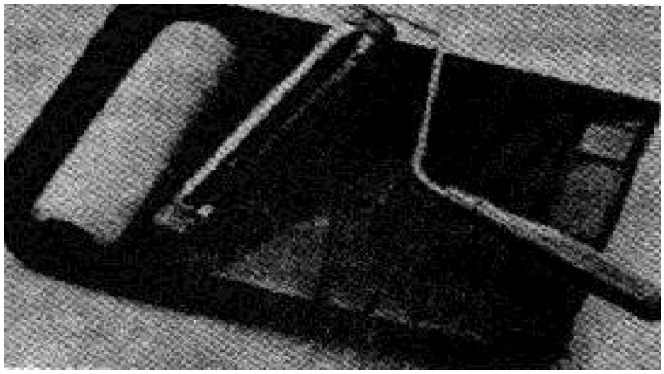
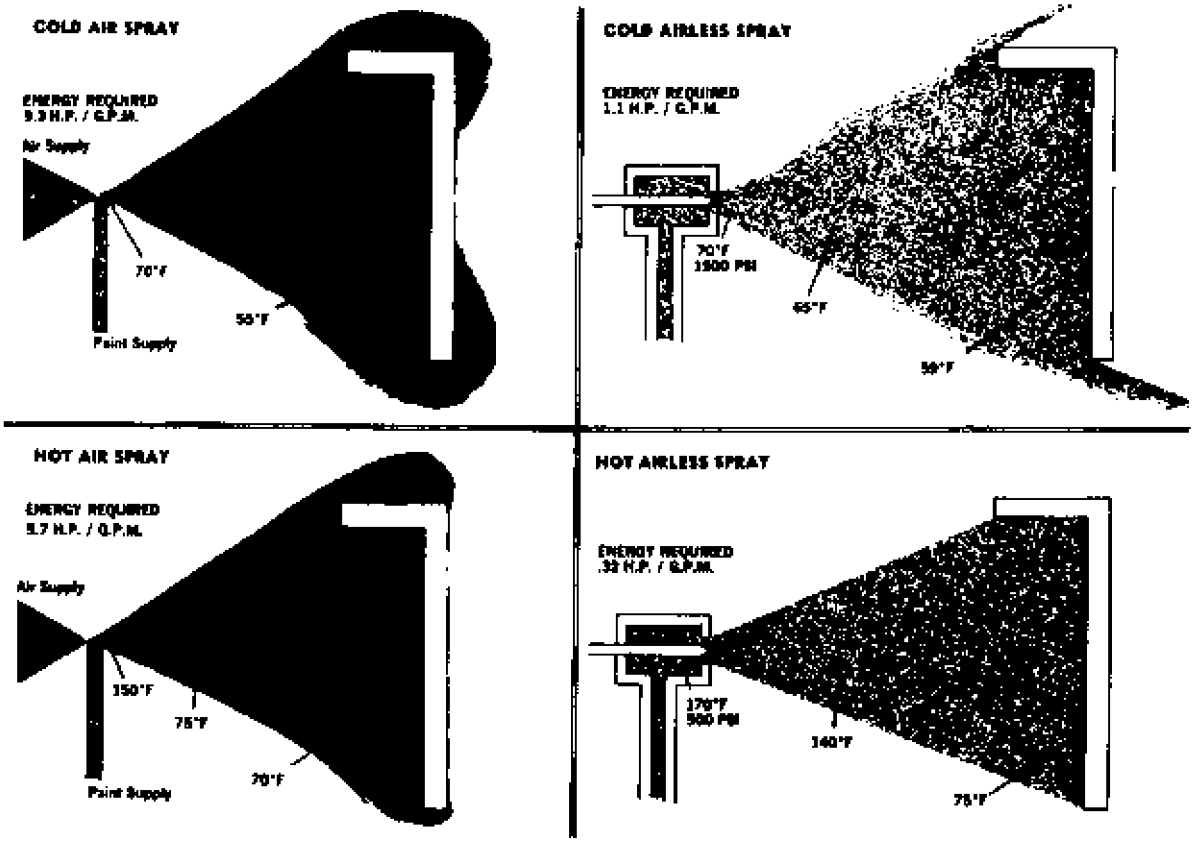


FIGURE 4-32
Roller and Tray

FIGURE 4-33
Roller and Wire Screen Attachment to Can



Dark Spots are Paint Particles

FIGURE 4-34
Basic Types of Spray

material is atomized by the air supplied through the central openings in the air cap (within the gun). Other air outlets on the outer ridges of the air cap shape the pattern of the material as it leaves the gun for the surface to be coated. This is the cheapest and most common spray technique but it tends to create excessive overspray because of the high ratio of air to paint used. Small jobs are sprayed with guns which can be attached to a quart paint container from which the paint is fed to the gun either by pressure or vacuum. (See Figure 4-38.)

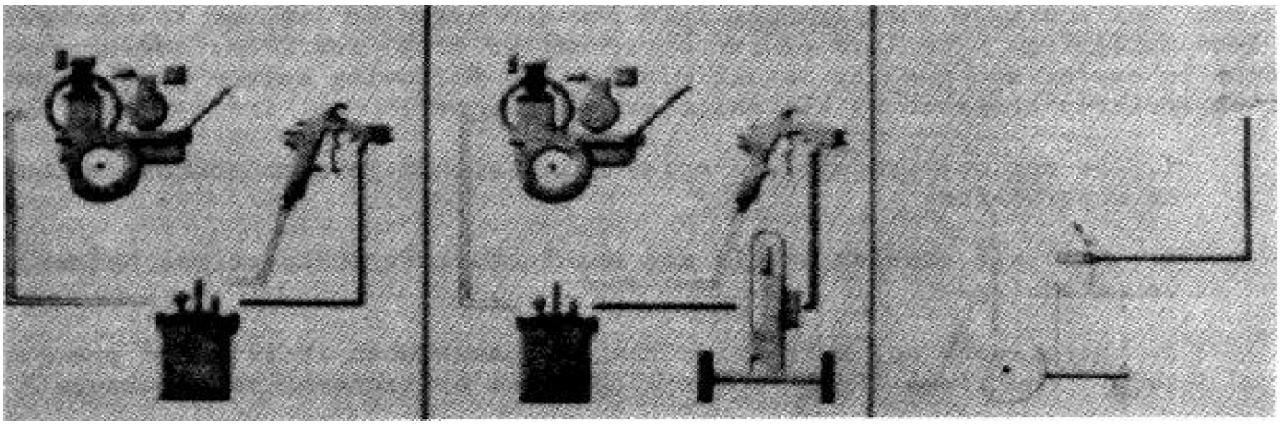
b. Airless Spray: In this method, coatings are sprayed by the use of hydraulic pressure alone. The equipment is similar to conventional spray except that the compressor operates a hydraulic pump. Atomization of the material is accomplished by forcing the material through a specially shaped orifice at between 1500 and 3000 psi. These pressures produce a highspeed stream of coating at the orifice. The high rate of speed plus the release of pressure causes atomization without compressed air; thus, there is no air turbulence to deflect the paint (the cause of overspray in the conventional method). The absence of air also reduces rebounding of the paint in crevices and corners, thus providing more uniform coverage. Airless spraying usually permits the use of products with a higher viscosity. Thus, less thinners are

TABLE 4-6
Roller Selection Guide

Type of Paint	Type of Surface		
	Smooth (1)	Semismooth (2)	Rough (3)
Aluminum	C	A	A
Enamel or Semigloss (Alkyd)	A or B	A	
Enamel undercoat	A or B		
Epoxy coatings	B or D	D	D
Exterior House Paint:			
Latex for wood	C	A	
Latex for masonry	A	A	A
Oil or alkyd - wood	C	A	
Oil or alkyd - masonry	A	A	A
Floor enamel--all types	A or B	A	
Interior Wall paint:			
Alkyd or oil	A	A or D	A
Latex	A	A	A
Masonry sealer	B	A or D	A or D
Metal primers	A	A or D	
Varnish--all types	A or B		
Roller Cover Key*		Nap Length (inches)	
A--Dynel (modified acrylic)	1/4-3/8	3/8-3/4	1-1 1/4
B--Mohair	3/16-1/4		
C--Dacron polyester	1/4-3/8	1/2	
D--Lambswool pelt	1/4-3/8	1/2-3/4	1-1 1/4

(1) Smooth Surface: Hardboard, smooth metal, smooth plaster, drywall, etc.
(2) Semismooth Surface: sand finished plaster and drywall, light stucco, blasted metal, semismooth masonry.
(3) Rough Surface: concrete or cinder block, brick, heavy stucco, wire fence.

*Comprehensive product standards do not exist in the paint roller industry. Roller covers vary significantly in performance between manufacturers and most manufacturers have more than one quality level in the same generic class. This table is based on field experience with first line products of one manufacturer.



A--Conventional Spray	B--Hot Spray	C--Airless Spray
This is the most commonly used type of spray equipment. It employs compressed air to perform two vital functions: first, to atomize the paint at the nozzle of the gun and second, to feed the paint under pressure from the supply tank, pump or cup to the gun nozzler. This type of system is the most simple and versatile of all spraying outfits. Wide use of this type of system over the past 40 years has led to the development and refinement of guns, nozzle., regulating devices, and paint supply units for practically every conceivable type of coating material and painting problem. As a result, heavy mastics, highly abrasive coatings and water thin liquids can now be sprayed by this method with equal ease. Conventional spray also provides more selectivity of spray pattern size, degree of atomization, and wetness of the coat than other methods and, therefore, is the most practical solution where these factors are important to the results of the job.	This method is primarily a modified form of conventional spray. It is comprised of the same elements of equipment even to the cap and tip of the gun, however, the difference lies in the addition of a heating unit which offers several benefits under certain operational conditions. With most organic paints which become more fluid at elevated temperatures (100° F to 180° F), the hot spray system is capable of applying higher solid content paints. This in turn produces heavier coats and reduces shrinkage during drying. With heated paint better atomization is accomplished with lower air pressure and at the same time overspray is greatly reduced. This method also permits painting when atmospheric temperatures are well below the usual 60° to 70° minimum. Better flowout is attained and pinholing common to certain paints is effectively overcome by hot spray.	In an airless system the spray is crested by the forcing of paint through a restricted orifice at very high pressure. Atomization of the paint occurs without the use of air jets, thus the name airless spray. Liquid pressures of 1500 psi and higher are developed in special air or electric operated high pressure pumps and delivered to the gun through a single hose line. This system provides a very rapid means of covering large surfaces with wide angle spray without overspray mist or rebound. The single small diameter hose line makes gun handling easy. The spray produced has a full wet pattern for quick film build, but requires extra care in lapping and stroking to avoid excessive coverage that would result in runs, sags, and wrinkles.

FIGURE 4-35
Types of Spray Equipment

required and better film build is obtained and production is increased. The need for just a single hose leading into the gun makes it lighter to handle and less fatiguing. The lack of overspray offers still two other advantages; cleanup is easier and masking is minimized. The following safety precautions must be strictly observed by all paint shop personnel:

1. Do not operate airless spray units without proper authorization or supervision.

2. Read all caution labels and manufacturer's instructions before using equipment.

3. Never work on, or repair, the equipment when it is under pressure. Shutting off the power alone does not release the pressure!

4. Always bleed line pressure immediately after using and before setting unit aside.

5. The spray cap should not be removed before unit is turned off and line pressure reduced.

6. WARNING: The airless spray gun should be treated as a loaded fire-arm.

7. WARNING: Never point an airless spray gun (capable of 4000 psi pressure) towards any part of the human body under any circumstances. Never put a hand or fingers in front of the spray gun.

8. WARNING: Obtain immediate medical attention for injuries, report the nature of the injury and the type of fluid or solvent involved.

c. Hot Spray: The hot spray technique can be adapted to either conventional or airless spray painting, but is most often used with the former. The paint tank and hose are heated to raise the paint temperature to 130° F-180° F. Introducing heat lowers paint viscosity thereby reducing the quantity of solvent needed. The resultant coating has higher solids and will produce greater film thickness per coat. Heat also allows for use of lower pressure thus reducing overspray and rebounding. Applying the coating hot at the gun allows for more uniform application at low environmental temperatures. Only materials specially formulated for hot spray application can be used.

d. Electrostatic Spray: Electrostatic spray units operate by producing an electrostatic charge which causes the applied paint to coat all exposed conductive areas uniformly. Specially formulated paints are required and painting is restricted to use on conductive substrates, such as steel or galvanized steel. Only one coat of paint may be applied to the base metal by electrostatic spray. However, on odd-shaped surfaces such as piping, fencings, channels and cables, their use is ideal because of the wraparound effect of the paint spray and minimal overspray.

4.6.5.2 Application. Most materials that can be brushed or rolled can be sprayed. Exceptions include very thick or stringy materials, some textured

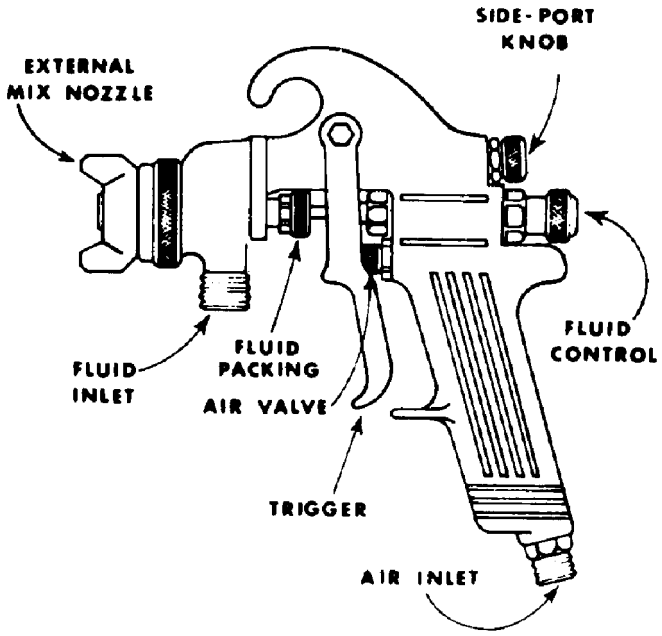


FIGURE 4-36
Modern Production Spray Gun

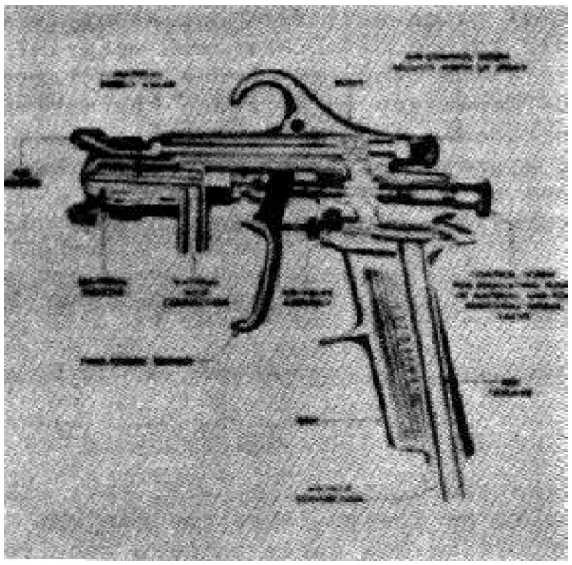


FIGURE 4-37
Spray Gun - Cross-Section

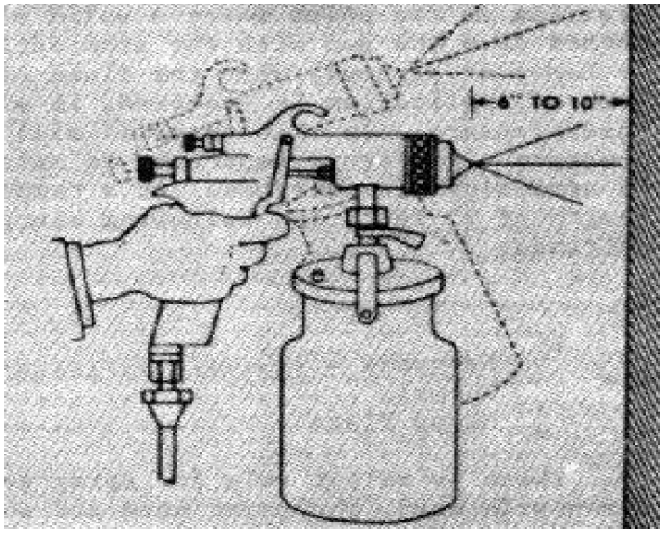


FIGURE 4-38
Spray Gun Held Perpendicular to Surface
to Prevent Uneven Deposit of Paint

materials and some rubber-based coatings. Control of the spray operation requires control over the following variables:

a. Viscosity of the Paint: It must be low enough to permit proper atomization but high enough to apply without running or sagging. Generally, a trial and error approach is required.

b. Pot Pressures: This determines the amount of material forced through the nozzle. It is controlled at the air regulator or at the gun.

c. Atomizing Pressures: This is the air pressure supplied to the gun to atomize the material and produce a uniform wet film. Too much pressure here will cause excessive overspray or a dry spray. Too little pressure produces a speckled or dimpled effect.

d. Air Cap on Spray Gun: This controls the amount and distribution of air mixed with the coating at the gun. The amount of air and air pressure controls atomization while the distribution of the air determines the shape of the spray pattern.

e. Material Orifice (nozzle): The size of this opening controls the amount of material that can be passed through the gun.

f. Air and Material Controls on Gun: These are for rough adjustment of amount delivered (See Figures 4-37 and 4-38.)

Adjust paint viscosity only when necessary and then according to manufacturer's instructions. Excessive thinning results in needless overspray, excessive runs and sags, poor hiding, and inferior surface protection.

During application, use the lowest material and air pressures that result in a quality finish with good flow out. Material pressure is best adjusted starting at the point where a solid stream of paint will flow out about 24 inches from the gun with the atomization air turned off. When the material is heavy or viscous, when the fluid hose is extra long, or when a more rapid rate of application is required, it will be necessary to increase the material hose pressure. In this case, it will be necessary to also increase the air pressure since it is important to maintain a proper ratio of material pressure to atomizing air pressure. At a temperature of 70° F, with a material length of 25 feet, the following air pressures are suggested for initial settings:

	(lb)
Lacquers	40-45
Enamels	35
Alkyd Flats	25-30

There is no set rule for spray gun pressures because they will vary with the nozzle used, the paint used and surface to be coated. Use the minimum pressure necessary to reduce overspray. Adjusting the spray pattern requires that the spray width adjustment screw be turned clockwise for a round pattern and counter-clockwise for a fan pattern. Turn the material control screw clockwise to increase the flow. As the width of the pattern is increased, increase the flow of the paint to maintain the same coverage over the wider area. Keep the spray gun 6 to 10 inches from the surface being coated. Holding the gun too far away causes "dusting," in which the paint solvent evaporates in mid-air and the coating hits the surface in a nearly dry state. Tilting the gun causes the paint to be more heavily applied in one area than another of the spray pattern. Use a free-arm motion and feather out at the end of the stroke by pulling the gun trigger after beginning the stroke and releasing it before the stroke is completed. When spraying corners, stop 1 or 2 inches short of the corner. Then hold the gun so as sweep up and down along the edge of the corner and hit both sides at the same time. (See Figures 4-38 through 4-44.)

4.6.5.3 Problems. Problems which may occur during spraying and their solutions are shown in Figure 4-45.

4.6.6 PAINT MITT APPLICATION. The paint mitt is a mitten made of lambskin with the wool exposed and lined to prevent paint leaking through to the user's hand. It is excellent for painting small pipes, railings, wrought iron and similar surfaces. (See Figures 4-46 and 4-47.)

4.6.7 CLEANUP. It is absolutely essential that all the tools and equipment be cleaned thoroughly immediately after use before the paint materials have a chance to harden. Remove as much paint as possible, then clean thoroughly with a compatible solvent. Clean 2 or 3 times in fresh solvent until no paint is noticeable. Then wipe clean and dry. With good care, all tools and equipment will last much longer and will always be in prime condition for use. After cleaning, wash all brushes with mild detergent and warm water; rinse in clear water, comb bristles straight with a metal comb, and place in brushkeepers or wrap in paper and allow to dry flat. (See Figures 4-48 through 4-51.) Wash cleaned rollers in mild detergent and water. Rinse in clear water and twirl to get rid of excess. (Spinners are available which hold the brush or roller cover.) Then stand on end to dry. When dry, cover to keep clean. Spray equipment should be cleaned thoroughly by placing clean solvent in pots and passing it through hoses and guns. When clean, empty, wipe clean, and dry. Clean pots separately. Use extreme care when cleaning airless spray guns inasmuch as the high pressures used are hazardous, especially when the spray head is removed. (See Figure 4-45.)

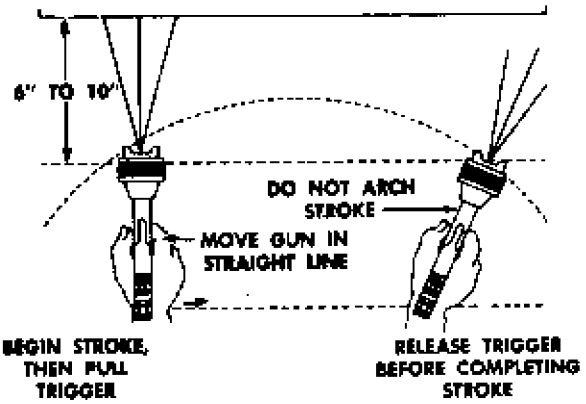


FIGURE 4-39
Proper Spray-Gun Stroke

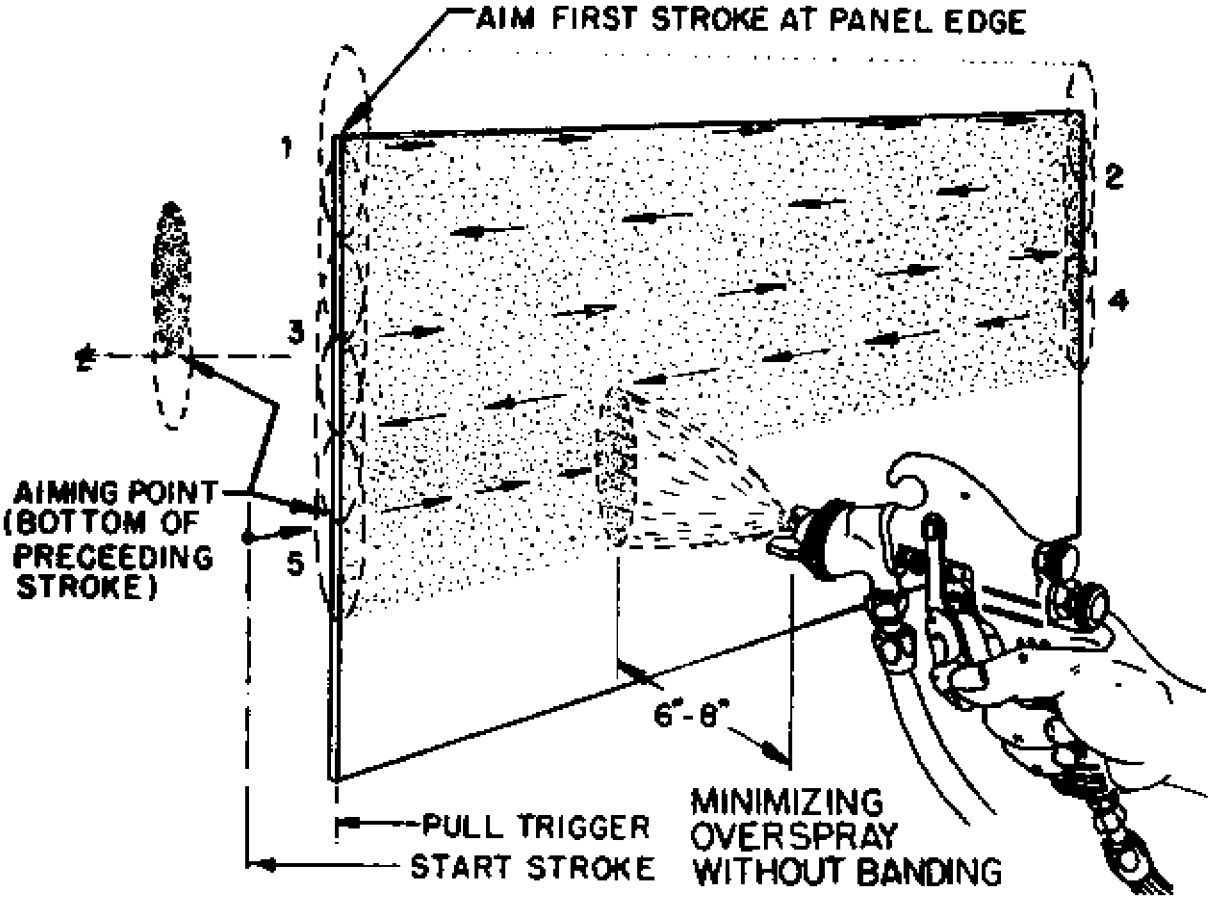


FIGURE 4-40
Spraying Large Flat Areas

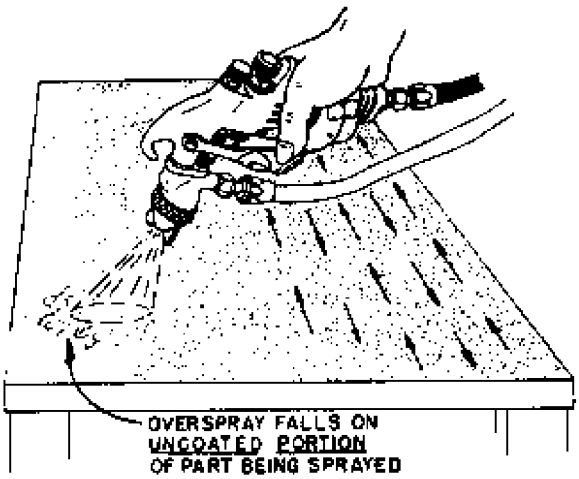


FIGURE 4-41
Spraying Horizontal Surfaces

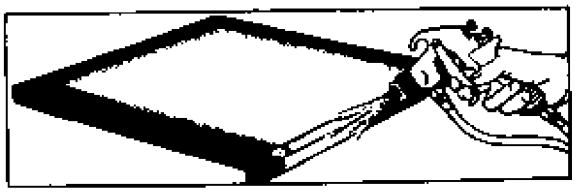


FIGURE 4-43
Spraying Edges and Corners

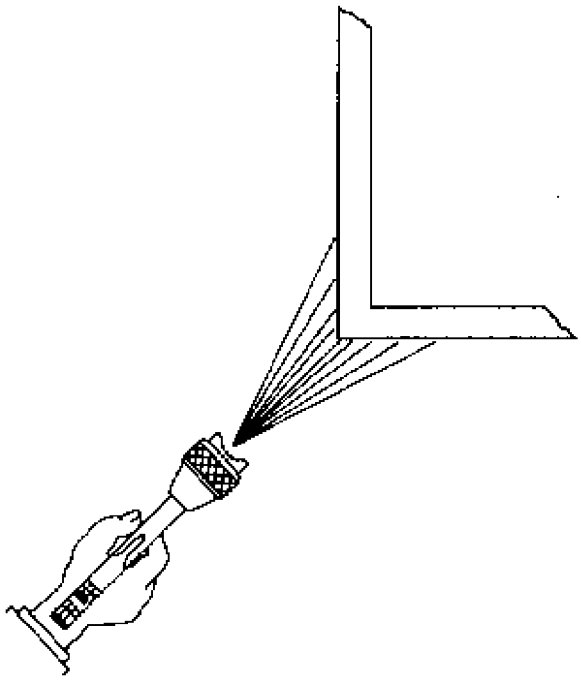


FIGURE 4-42
Spraying Corners

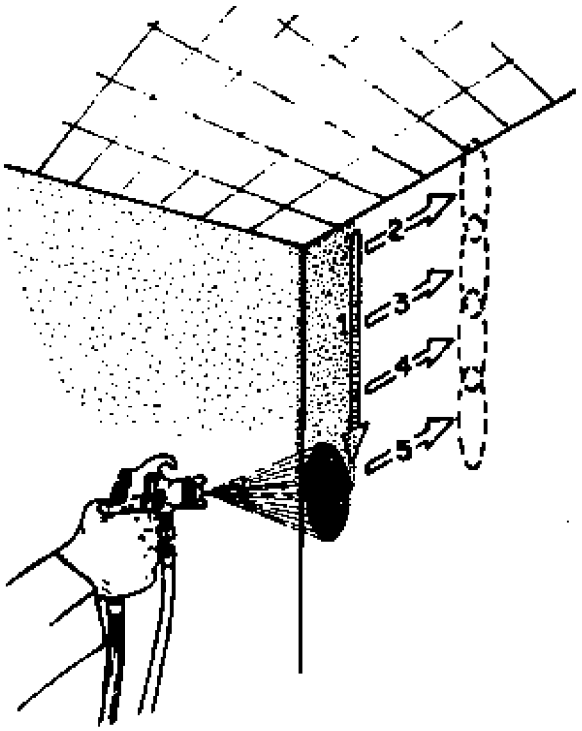
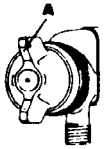
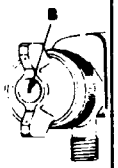
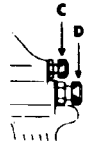
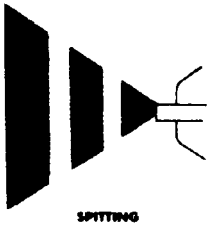
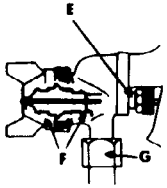


FIGURE 4-44
Painting Interior Corners

Faulty patterns and how to correct them

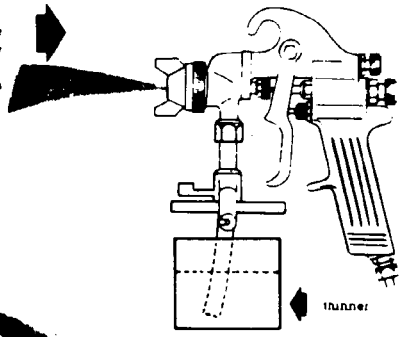
Pattern	Cause	Correction
	Dried material in side-port "A" restricts passage of air through it. Result: Full pressure of air from clean side-port forces fan pattern in direction of clogged side. 	Dissolve material in side-port with *thinner*. Do not poke in any of the openings with metal instruments.
	Dried material around the outside of the fluid nozzle tip at position "B" restricts the passage of atomizing air at one point through the center opening of air nozzle and results in pattern shown. This pattern can also be caused by loose air nozzle 	If dried material is causing the trouble, remove air nozzle and wipe off fluid tip, using rag wet with thinner. Tighten air nozzle
	A split spray or one that is heavy on each end of a fan pattern and weak in the middle is usually caused by (1) too high an atomizing air pressure, or (2) by attempting to get too wide a spray with thin material.	Reducing air pressure will correct cause (1). To correct cause (2), open material control "D" to full position by turning to left. At the same time turn spray width adjustment "C" to right. This will reduce width of spray but will correct split spray pattern. 
 SPITTING	(1) Dried out packing around material needle valve permits air to get into fluid passageway. This results in spitting 2) Dirt between fluid nozzle seat and body o. a loosely installed fluid nozzle will make a gun spit (3) A loose or defective swivel nut on siphon cup or material hose can cause spitting.	To correct cause (1), back up knurled nut (E), place two drops of machine oil on packing, replace nut and tighten with fingers only. In aggravated cases, replace packing.  To correct cause (2), remove fluid nozzle (F), clean back of nozzle and nozzle seat in gun body using rag wet with thinner, replace nozzle and draw up tightly against body. To correct cause (3) tighten or replace swivel nut (G).

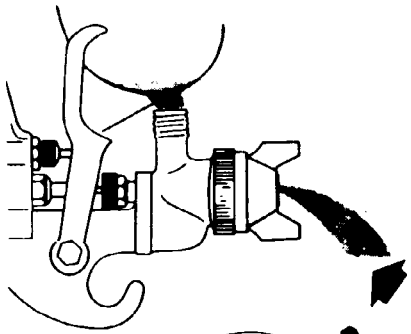
Faulty patterns and how to correct them

Pattern	Cause	Correction
	A fan spray pattern that is heavy in the middle, or a pattern that has an unatomized "salt-and-pepper" effect indicates that the atomizing air pressure is not sufficiently high	Increase pressure from your air supply. Correct air pressures are discussed elsewhere in this instruction sheet

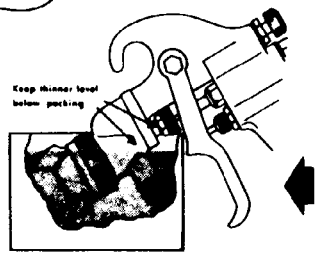
Pointers on cleaning

When used with a cup, thinner or suitable solvent should be siphoned through gun by inserting tube in open container of that liquid. Move trigger constantly to thoroughly flush passageway and to clean tip of needle





When the gun is used with a pressure tank or gravity bucket, remove the hose, turn the gun upside down and pour thinner into the fluid opening while moving the trigger constantly. This will flush all passageways.



It is extremely poor practice to place an entire gun in thinner. When this is done, the solvent dissolves the oil in the leather packing and causes the gun to spit.

It is good practice to place the nozzle and fluid connection in thinner. Vessel used should be shallow enough to prevent thinner from reaching packing.

FIGURE 4-45
Spray Gun Adjustments and Cleaning

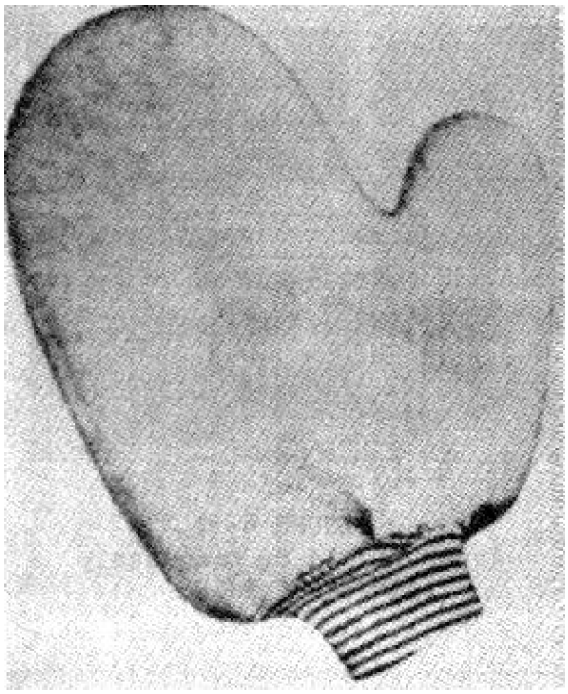


FIGURE 4-46
Paint Mitt

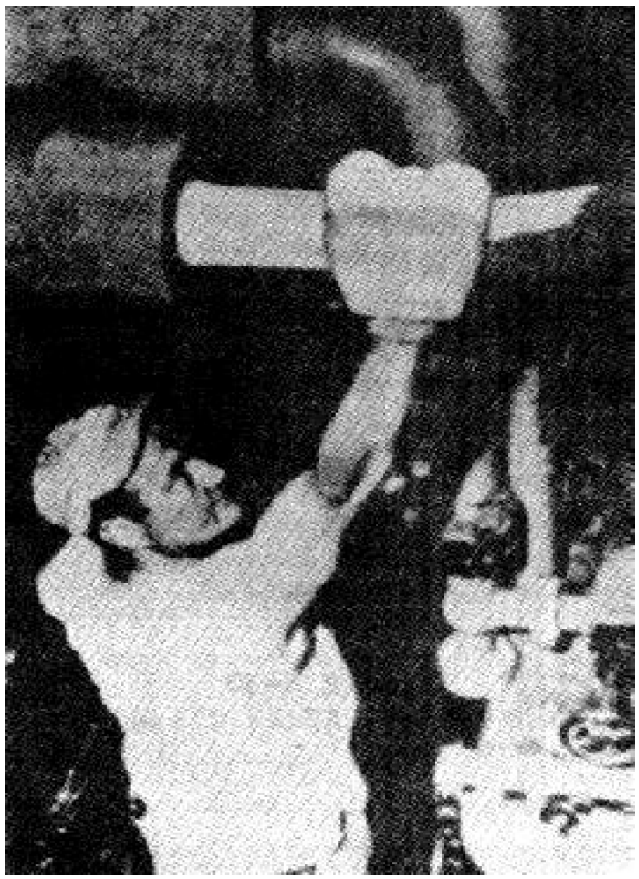


FIGURE 4-47
Paint Mitt In Use

FIGURE 4-48
Remove Excess Paint

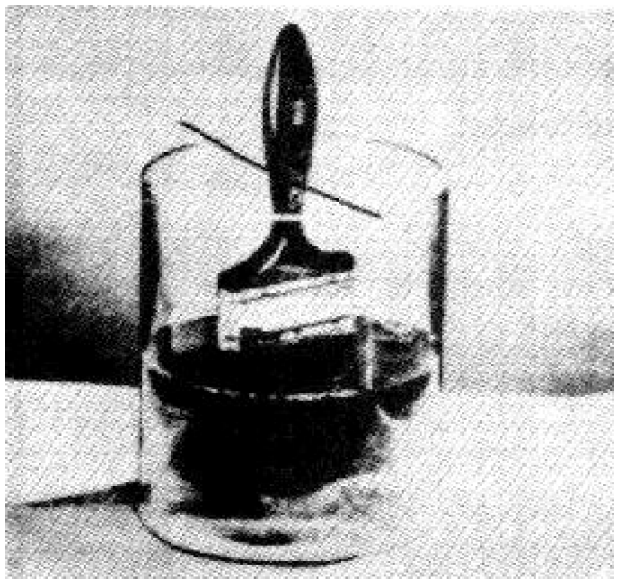


FIGURE 4-49
Clean Brush Until No Paint
is Noticeable

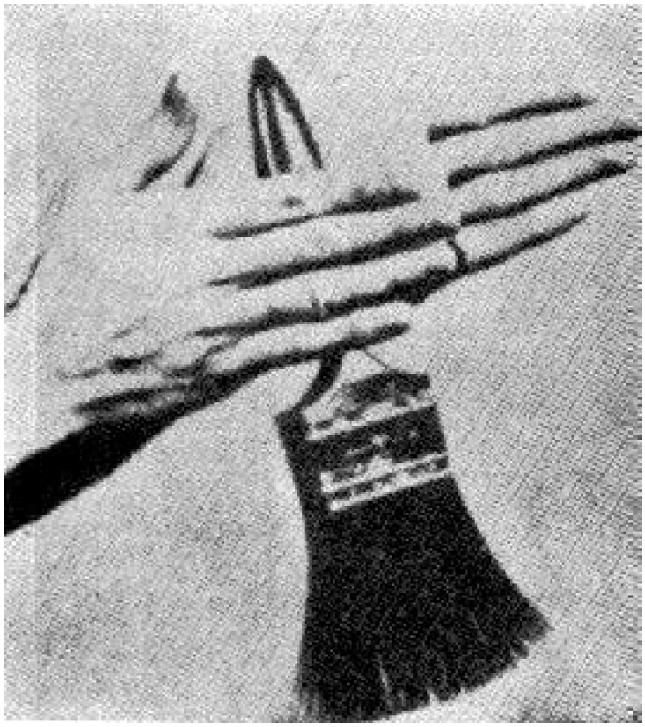


FIGURE 4-50
Twirl Brush After Cleaning

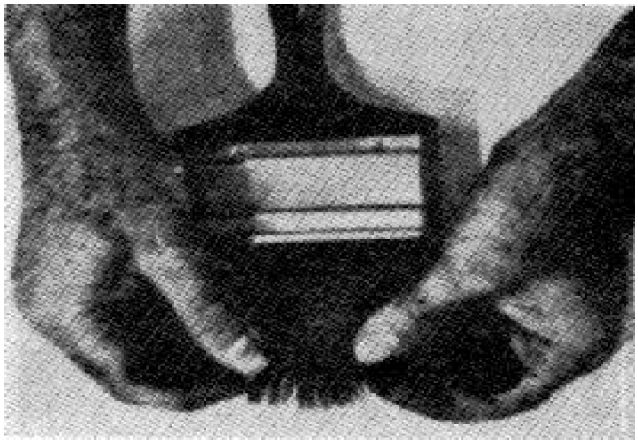


FIGURE 4-51
Brush Should Be Completely
Free of Paint